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The Danish Biological Station

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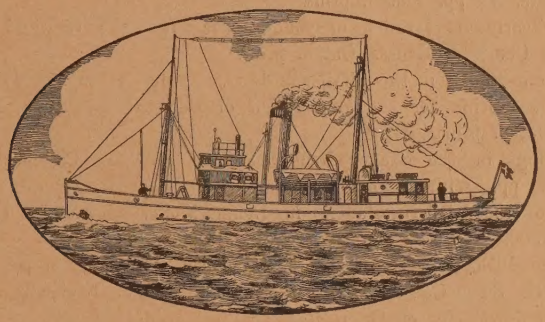

XLII.

1937.

By

H. Blegvad, Ph. D.
Director

Copenhagen. C. A Reitzel.
1938.

The Reports from the Danish Biological Station (Nos. I—XXI) are published in the official Danish "Fiskeri-Beretning" for the years 1890—91 until 1912. After this year they appear as special publications. The Reports I—XXXII are edited by the late Dr. C. G. Joh. Petersen, the Reports XXXIII—XXXVI by Dr. A. C. Johansen and the later Reports by Dr. H. Blegvad.

I. *C. G. Joh. Petersen:* Fiskenes biologiske Forhold i Holbæk Fjord. (1890—91)*) 63 pp. 1 Chart. Out of print.

II. *Idem:* On the Eggs and Breeding of our Gobiidæ. (1891—92.) 9 pp. Two Plates. Out of print.

III. *Idem:* The Pelagic Life in Fænø Sound etc. (1892—93.) 38 pp. Tables. Out of print.

IV. *Idem:* On the Biology of our Flat-fishes and on the decrease of our Flat-fish Fisheries. (1893—94.) 146 pp. 2 Plates. 1 Chart. Many Tables. Out of print.

V. *Idem:* The common Eel (*Anguilla vulgaris* T.) gets a Particular Breeding-dress before its Emigration to the Sea. (1894—95.) 35 pp. With 2 Plates.
Etc. 64 pp. Out of print.

VI. *Idem:* The Yearly Immigration of young Plaice into the Limfjord etc. (1895—96). 48 pp. 1 Chart. 2 Tables. Out of print.

VII. *Idem:* Plankton-Studies in the Limfjord. 1897. 23 pp. 1 Map. 4 Tables. Out of print.

VIII. *Idem:* An Otter-Seine for the Exploration of Deeper-Seas. 1898. 24 pp. With 10 Figures. Out of print.

IX. *Idem:* Trawlings in the Skager Rack and the Northern Cattegat in 1897 and 98. 1899. 56 pp. With one Map. Out of print.

X. *Idem:* List of the "Aalerusestader" in Denmark etc. — Smaller Communications. 1899 and 1900. 37 pp.

XI. *Idem:* I. The Biology of the Cod in the Danish Seas. II. On other Codfishes in our Seas. III. Some General Observations on Protection, Legislation etc. IV. Alterations and Improvements on Otter-seines for Zoological Purposes. 1900 and 1901. 44 pp.

XII. *Idem:* I. Where, and under what Conditions, can the Eggs of Plaice be developed into Young Fish within the Skaw? II. On the Young Stages of the genus *Zeugopterus.* (With one Plate). III. Can we enter into Competition with the Foreign Steam-trawlers in our Seas outside the Danish Territorial Limit. 1902 and 1903. 33 pp.

XIII. *A. Otterstrøm:* Eggs and Young of Fishes in the Danish Waters. (Investigations during 1904 and earlier years.) 1903 and 1904. 85 pp.

XIV. I. *C. G. Joh. Petersen:* The Influence of Light on the Migrations of the Eel. II. *K. I. Gemzøe:* Age and Rate of Growth of the Eel. 1906. 39 pp.

XV. *Idem:* I. First Report on the Oysters and Oyster Fisheries in the Lim Fjord. (70 pp.) 1908.

XVI. *C. H. Ostenfeld:* On the Ecology and Distribution of the Grass Wrack (*Zostera marina*) in Danish Waters. With 9 figures. 1908. 62 pp.

XVII. *C. G. Joh. Petersen:* II. Second Report on the Oyster and Oyster Fisheries in the Lim Fjord. 1908. (24 pp).

XVIII. *C. G. Joh. Petersen:* I. The Yield of the Limfjord fisheries in recent years and the transplantation of Plaice in 1908. With 6 tables and 1 Chart. II. Biological investigations on the stock of Plaice in the Limfjord. With 3 Tables. III. The Yield of the Prawn fishery from 1885—1907 and its improvement by means of protection. With 3 Tables. 25 pp. 1909.

XIX. *Idem:* Some Experiments on the Possibility of combating the harmful Animals of the Fisheries, especially the Whelks in the Limfjord. 20 pp. 1911.

XX. *C. G. Joh. Petersen* og *P. Boysen Jensen:* Valuation of the Sea. I. Animal Life of the Sea-Bottom, its food and quantity. With 6 Tables, 3 Charts and 6 Plates. 81 pp. 1911.

*) The figures in ( ) refer to the "Fiskeri-Beretning" for the years quoted.

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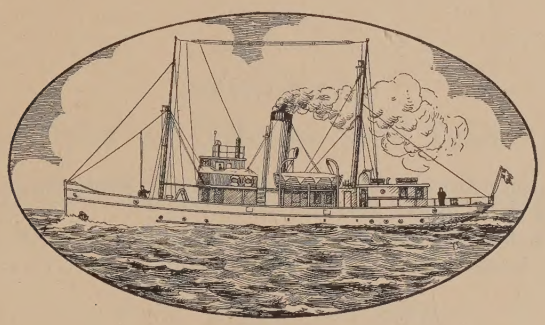

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On Methodical Liberations of Salmon and Trout Fry in Watercourses with Special Reference to the Gudenaa Area.

By

C. V. OTTERSTRØM

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Throughout a long series of years liberations of fry of salmon and trout are being carried out, but our knowledge of the theoretical basis of this work is still insufficient for a calculation of the most profitable density of the stock to be liberated. Most Danish streams run through glacial or post-glacial deposits and have a comparatively slight fall, thus showing a fairly uniform breadth and character for long continuous distances: in the case of such streams, at any rate, it is possible to make calculations stating with a certain degree of accuracy the most profitable amount to be put out. In a previous paper (23) the present author briefly deals with the same subject; every year, however, the Danish Biological Station examines new streams and on the basis of this work plans new liberations, thus contributing to the increase of our knowledge. The aim of the present paper will be to bring a detailed treatment of the whole of this matter, a problem which grows more and more urgent as our fresh waters are being barred by weirs and deteriorated by pollution and agricultural arrangements.

If our stock of trout[1]) is to be maintained or improved, it will be necessary nearly everywhere in Denmark to support it by liberations of fry or older fish. Firstly, the stock of trout has been reduced to such a degree in many places, that the number of breeding fish is too small as compared to the size of the areas in which young trout might grow up; secondly, the access to these areas is obstructed by fishing gears in the fjords and streams and particularly by weirs in the streams. Large and in themselves suitable areas of the streams get no natural trout fry, or at any rate only brown trout with a small number of eggs and possibly with some hereditary inclination of non-emigration will spawn here. This condition may be remedied by liberations of fry of artificial hatching.

Even if the conditions of ascent are favourable, so that a natural spawning of sea-trout may take place, there may be reasons for a liberation of fry. It is a well-known fact that we get a far more efficient fecundation of the trout roe by stripping and artificial fertilization than by the natural spawning in the watercourses[1]). In the latter places a much larger percentage of eggs is no doubt lost than in the hatchery where the loss is only about 1—10 %. It must be admitted, however, that fry of the natural hatching are often more vigorous than the fry procured by the ordinary methods of the hatcheries (Hein 12—14). It seems to be certain that the capture of spawning fish, stripping, artificial fecundation and hatching of the roe will generally yield a much larger number of fry; furthermore, the natural spawning will mostly be confined to a comparatively limited area of the stream whereas the fry of artificial hatching may be distributed over a much vaster area, the nutrients of which are consequently turned to account.

In practice only fry and older fish will be used for the liberation. Where conditions of the bottom of the watercourse are not very good, the use of youngs of artificial breeding (i. e. fry fed for some weeks in feeding channels; not in use in this country)

[1]) For brevity's sake I use the word trout, this term, here and in the following, meaning both salmon and trout.

[1]) It is true that Jacob D. Sømme (36), states that by digging out roe in the spawning places he found, in three cases, 89, 94 and 98.5 % of the eggs to be fertilized, but undoubtedly such results are infrequent. It may be added that in one spawning place Sømme found that about 35,000 eggs had been spawned, but only about 150 of them had got down among the stones of the spawning place while the rest had been carried further down the stream. Of the eggs dug out some distance below the spawning place only about 20 % were found to have been fertilized.

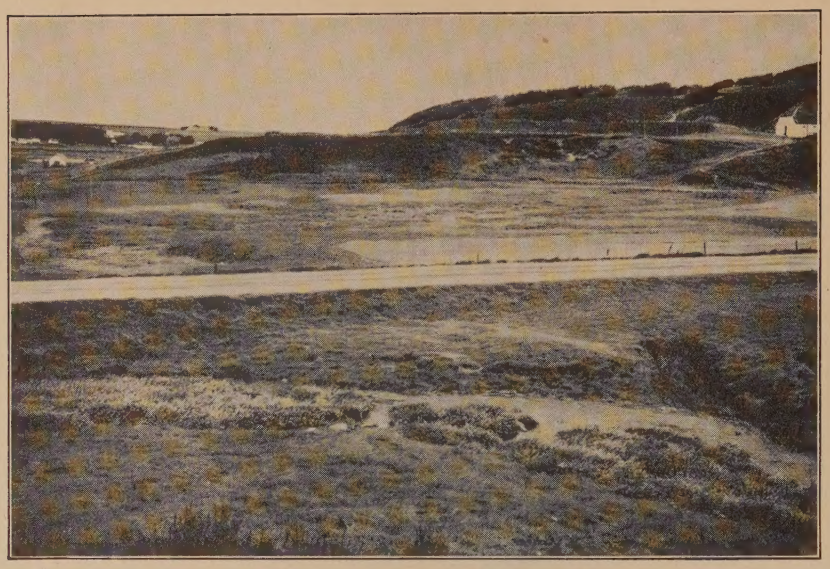

Figure 1. Kovadsbæk, a tributary of the Lindenborg Aa. The brook, originating from a neighbouring spring, has preserved its natural state. Broad and shallow (250 × 10 cm), rapid current, stony-gravelly bottom. Open to light; rich vegetation: water-parsnip (*Sium*), speedwell (*Veronica anagallis*); on the stones green algae (*Cladophora*) and at the bank duckweed (*Lemna minor*). Animals: freshwater-shrimp (*Gammarus pulex*), larval sandflies (*Simulium*), snails (*Ancylus*) etc.; the stream must be considered pre-eminently fitted for liberation of fry. 2nd Sep. 1936.

Figure 2. A tributary of the Horndrup Aa, south of Taaning. The brook is about 1 m broad and 5 cm deep, has a rapid flow and gravelly and stony bottom. The bed is irregular, with windings and small "pools". No vegetation in the brook because it is overshadowed by trees; this in itself is no advantage but causes that we are able to see the bottom on the photograph. Rich animal life, i. a. freshwater-shrimp (*Gammarus pulex*). — Photographed during a dry period. — Good place of liberation for fry of salmon or trout. 9th August 1936.

might well be preferred, but otherwise the liberation of tiny fry is presumably just as efficient and at any rate somewhat cheaper. Older fish (of 1—1$^1/_2$ year) may come to be extensively used for the liberations because they can be used for the areas of the streams that are too large for the tiny fry but otherwise well fitted, and for areas of brackish water. But older fish are much more expensive than fry, and so it is reasonable course to begin with a utilization of such areas as may be populated with fry. If, after this, a further development of the stock of trout is aimed at, it may be brought about by the liberation of older fish in other parts of the watercourses. Indeed, the statistical investigations carried out by J. P. Jacobsen and A. C. Johansen (18) in the Gudenaa seem to indicate that the liberation of fry has been more efficient as compared to the costs than has the liberation of older fish: at the Frisenvold Fish-Weir the liberation of 10 000 specimens of tiny salmon fry yielded an additional catch of 14 summer salmon while we find an additional catch of 19 summer salmon per 10 000 half-yearlings put out. Possibly these considerations have no universal validity, but at any rate the problem in hand will be the liberation of fry, and so the following pages deal exclusively with such liberations.

Of course the fry to be liberated should be sound and vigorous. If it is put out at a tiny stage of life there is less probability of its being attacked by any of the parasites (*Costia*, *Chilodon*, *Cyclochaeta*, *Ichthyophthirius*) that often infest the fry going too long in the hatching boxes. The greatest risk will undoubtedly be attached to the fry being liberated too late, so that the youngs begin to starve. It must be considered most advisable to carry out the liberation while there is still something left of the yolk-sac and as soon as the youngs have risen to an edgewise position: at this time the fry liberated need not venture out on a hazardous search for food during the first days after the liberation.

The fry will generally be much better protected against diseases in the watercourses than in the hatchery and the fish ponds where the probability of contagion rises enormously on account of the density of the population. However any watercourse that receives an afflux from a trout pond farm infected with "staggers" (*Lentospora cerebralis*) must be considered more or less unfitted for the liberation of trout fry (but not of older trout) for a very long distance below because the infecting spores of *Lentospora* are carried along with the water (Schäperclaus 30).

The transport of small quantities of fry may be carried out by means of milk-pails or similar vessels. Buschkiel (6) recommends special milk-cans with a container for ice; in such a pail with about 16 l of water you can carry 2 500—5 000 pieces of fry according to the duration of the transport, the temperature of the water and the degree to which it is stirred. If the temperature is kept down on 8° C. and the water is stirred, it is possible to carry 5 000 pieces of fry in such a pail for 6 hours without running the risk of debilitating the fish. A transport of the fry to be liberated in a number of smaller pails should be preferred to the use of a few large vessels, which are unmanageable and tempt you to put out the fry as closely as possible to the conveyance, so that no proper regard is paid to the conditions of bottom. An aeration of the transport water by means of compressed oxygen always involves the risk of hurting the fry; at any rate it should be carried out most cautiously.

In earlier times special care was taken of the fry not being exposed to sudden variations of temperature during the transport or the liberation, and it was considered unadvisable to raise or lower the temperature by more than 1° per 5 minutes. But experiments (Alm 5) have shown that fish are highly indifferent to sudden changes of temperature and that differences occurring in practice in this country during the liberations of fry of salmon or trout play no part whatever. Only the liberation into very cold (below 5° C.) or very hot water (above 25° C.) may be hurtful to the fry.

The place of liberation is of very great importance. Ideal localities for the liberation of fry are such places in which the bottom consists of coarse gravel or pebbles among which the fry can find shelter; where there is a moderate current (1 m. in about 5 seconds); where the depth of water is 5—25 cm. and where there is ample food consisting of small animals (Figs. 1—3). Such ideal conditions do not by far prevail anywhere in our streams, and the fry may thrive under less favourable conditions although certain things are necessary.

Shelter is unnecessary for the fry of a pond but is undoubtedly necessary for fry living in a watercourse. If no shelter is found, the trout fry will

Figure 3. Gyldensaa (Bornholm). The bed of the brook is full of stones and rocks (granite), and so the real breadth of the stream is difficult to measure. At present there is but little water here, but sometimes the stream will swell very much; however, the trout fry will easily find shelter from the rapid current behind the stones. The stream is overshadowed by a wood and therefore void of vegetation. 15th July 1936.

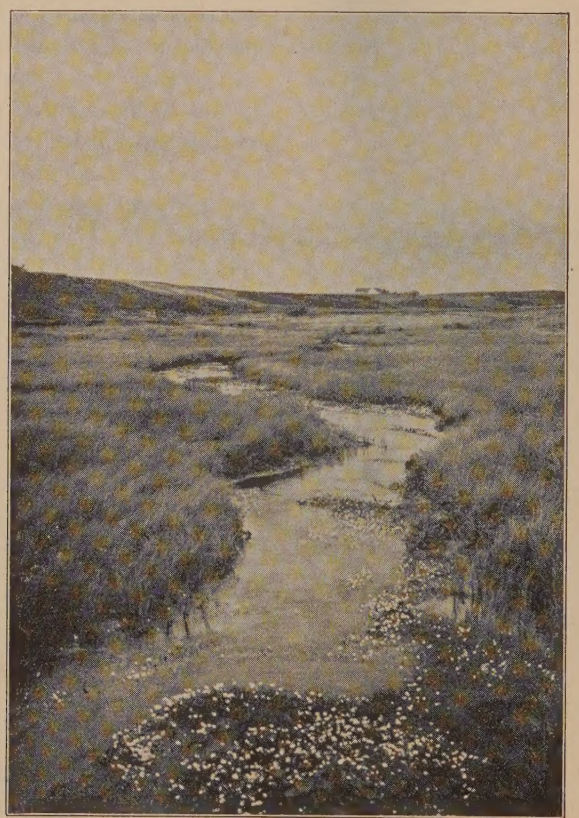

Figure 4. Aaresvad Aa (tributary of the Karup Aa) viewed in an upward direction from a bridge east of Aarestrup. Uncleared reach with flowering water-crowfoot (*Batrachium*), marsh marigold (*Caltha palustris*), willow-herb (*Epilobium*), water-parsnip (*Sium*) and duck-weed (*Lemna minor*). Suitable for trout fry but of little value when cleared. 25th July 1922.

soon be devoured or it will disappear from the area for the purpose of finding more suitable localities, in both of which cases the liberation must be considered a failure. Shelters may consist of inequalities of the bottom, generally stones (Figs. 2, 3 and 6), but are also made up of suitable plants (Figs. 1 and 4), e. g. water-crowfoot (*Batrachium*) and starwort (*Callitriche*). It should be remembered, however, that a watercourse, which looks excellent with vegetation gathered in dense clusters, may change its character in the course of one day when it is cleared out and left as a barren and level channel with smooth sandy bottom (Fig. 13). It will not be as bad as that where the bottom is stony, and as a stony bottom generally means a rapid fall, a clearing of such localities will not be so necessary for agricultural purposes. Tree roots and brinks are hardly of great value to the fry: such shelters are undoubtedly preferred principally by adult trout.

The current will in most watercourses be rapid enough for trout if other facts do not come into play. Lack of current will cause a lessened oxygenation through the surface, so that a pollution will assert itself, and trout are very sensitive to shortness of oxygen. Lack of current generally induces accumulations of mud thus making the bottom of the stream soft and unfit for shelter. Lack of current will bring about great variations of temperature, too high temperatures in summer and possibly freezing to the bottom in winter. During dry periods a slow current will often stop altogether.

The size of the watercourse is of some importance. At certain depths of water we generally find larger fish, such as larger-sized trout, grayling, pike, eel, roach, dace or perch. Nearly all of these fish may mean a direct danger to the tiny trout fry, and so the most eligible places of liberation would be such localities where no other fish at all are found. Such localities cannot by far always be found, but if sufficiently shallow areas are chosen, no other fish than threespined stickleback, minnow and small trout will occur very frequently, and they do not seem to be very dangerous. There can hardly be any objections against a liberation even in very shallow water (with a depth of a few cm.) with adequate current, provided that the water level cannot suddenly sink (on account of the activity of man); but in water of a depth of more than 0.5 m. liberations should be avoided.

The breadth of the stream is of some importance, too, because a broad watercourse is of comparatively less value than a narrow one as far as the area is concerned. If the stream is less than 1 m. broad, there will in most areas be no great difference between the central part and the water along the banks. But if the stream is broader, there will often be comparatively more food for the trout fry along the banks than in the middle where the water is generally a little deeper. But here there are many possibilities: in a brook that has recently been cleared out the sandy and level bottom will perhaps afford equally bad conditions everywhere (although much more insects will fall into the lateral regions from the grassy banks than into the central part). If the current cuts in along one bank and forms gravelly banks in the middle of the bed, the latter will perhaps afford a better retreat of the fry. If the brook is stony, so that the water will tend to broaden the stream instead of cutting into the bottom, we find a brook that is not much deeper in the middle than along the banks, and even in a rather broad rivulet of this kind the whole area from one bank to the other may be of equal value (Figs. 1 and 6). But on the whole we may safely say that watercourses with a breadth of more than about 1.5 m. are of less nutritive value to the trout fry in comparison with their area than are the lesser streams. The broader the stream the smaller the value of the area, a fact, however, which may be disregarded as far as this country is concerned because streams of more than a few metres in breadth will generally be unfitted for the liberation of fry. So it seems sufficient to put down the rule (under certain conditions without validity — see Fig. 6) that watercourses with a breadth of more than 1.5 m. may be estimated to possess only $^2/_3$ of the nutritive power per unit of area that is contained in a corresponding but narrower stream.

The nutritive value of the watercourses to the trout fry depends partly on their contents of the animals preyed upon by the trout fry, partly on the recruiting of these animals from elsewhere. An investigation has been made on the food of trout fry in "natural ponds" (Schäperclaus 29), but we do not know very much of the food of salmon and trout fry in free waters during their first year of life though Alm (1, 3), Dahl (8), Hessle (15), Olstad (21) and others have touched this problem. Alm found that the food of the youngs of salmon and trout consisted nearly exclusively of

Figure 5. Aastrup Bæk viewed from bridge near its outfall into Sneum Aa. 3 m. broad and 10—20 cm. deep with deeper "pools"; natural bed; stony, gravelly and sandy bottom. Starwort (*Callitriche*), water-crowfoot (*Batrachium*), water-flag (*Iris pseudacorus*), forget-me-not (*Myosotis palustris*). Some vegetation has been mowed off, but much is left. Rich animal life. Excellently suited for trout fry. 14th July 1922.

Figure 6. Sneum Aa at Hjortkjær. In spite of its breadth at this place the river is well fitted for liberation of fry having an excellent gravelly bottom and a depth of only few cm. 18th July 1927.

insect larvae, particulary of larval caddis-flies (*Trichopterae*), may-flies (*Ephemerids*) and midges (*Chironomids*). Schäperclaus found that larval Chironomids were by far the most important food matter of the youngs of the brown trout. But both in the ponds examined by this author and in Alm's Swedish rivers the freshwater-shrimp (*Gammarus pulex*) was lacking completely or was rare whereas in most Danish watercourses it is the most prominent food animal[1]). So these investigations cannot properly be used for direct comparisons with the watercourses of this country; but to all probability small Gammarus will be an excellent food matter for the fry of salmon and trout — that this is the case with larger trout is known i. a. from the investigations carried out by Dahl and Olstad — and its high nutritive value appears from Cornelius' experiments (7). The young trout undoubtedly selects its food among all the animal forms of suitable size that occur in the watercourses. It is evident that a thinly populated water must afford bad conditions of nutrition; on the other hand it is not certain, although likely, that a stream abunding in gammarids but containing few other edible organisms (which is not very infrequent) is a good habitat of the trout fry. Such waters must be considered best that contain many different forms of animals in ample numbers; this seems to be the case particularly in the upper parts of the watercourses such as fountains and brooklets with rapid fall, stony bottom and a vegatation which is not kept down by clearings or by overshadowing.

The clearing removes the favourite shelters of the trout and at the same time the life basis of its food animals. The total quantity of larvae, snails and partly gammarids are thrown ashore or flow down the stream; to the animals that fall off the plants on their removal there is not much left to eat — perhaps with the exception of the gammarids which, on account of their vivacity, seem to be able to thrive fairly well on the food material that is flowing down the stream. In brooks that have recently been cleared an abundance of gammarids are often found in the few plants left near the bank (*Glyceria*, etc.). After the clearing a shorter or longer time will pass until the vegetation has once more grown to such a size as to form the basis of a stock of food animals; but if the latter show a life cycle of one year only, it will easily be understood that they are apt to be highly influenced by a regular washing away once a year. There can be no doubt that the stocks of food animals of salmon and trout fry in the watercourses suffer very much from the clearings although the latter do not always affect these fish in an unfavourable way. A brook in its natural state running through meadow-land often shows a characteristic serpentine run with a comparatively gentle slope and a luxuriant vegetation consisting of horsetail (*Equisetum*), bur-reed (*Sparganium*), water-thyme (*Elodea*), tench-weed (*Potamogeton natans*) and similar forms that prefer a rather slow current (and soft bottom?). If such a stream is regulated by cutting through the serpentines, and if the vegetation is dug out or mowed off annually, it gets a steeper slope, a more rapid current, harder bottom and a somewhat different vegetation, in wich starwort (*Callitriche*) and water-crowfoot (*Batrachium*) play a more prominent part than before. The stream has changed from a roach-eel-pike-water into a trout-water. So we may suppose that regulations and clearings have formed a great many trout waters, but at the same time a good deal of streams, which were formerly good trout waters, have been severely damaged by similar transactions.

Shade exercises a strong influence upon the aquatic plants. They thrive only in full light, and in places to which such light is admitted we often find the stream to be nearly filled with vegetation (Figs. 1, 4, 8). If such a stream enters a wood, or shading alders grow up along the banks, the aquatic plants disappear at once (Figs. 2, 3). This is also the case if the bed of a brook has been lowered, so that a vegetation developing on the edge of the banks overshadows the surface; in this way ditches may be overshadowed completely by grass, and meadowsweet (*Spiraea ulmaria*) and nettle (*Urtica dioeca*) may cover rather broad streams (Figs. 9—10). In such brooks the vegetation and, consequently, most food animals of the trout fry are lacking; only Gammarus — presumably living on drifting plant particles — will sometimes occur in fairly considerable numbers.

A high degree of pollution makes a stream unsuitable for salmon and trout, especially for the tiny fry. In practice a distinction can be made between the comparatively rare sudden pollutions originating from dischargings of calcium hypochlorite, bursting of liquid manure tanks etc., and generally having the character of poisonings, and pollutions of a more constant nature arising from permanent

[1]) In many, perhaps all streams of Vendsyssel Gammarus is absent (25).

Figure 7. Sugebæk (tributary of Borresø). The bed is dry now, but in spring the brook seems to be pre-eminently suited for trout fry. 18th June 1919.

Figure 8. Albæk, a tributary of the Skjærum Aa. The brook, showing some regulations, is 120 cm. broad, 40 cm. deep and has a fairly rapid flow. It has not been cleared out in this year and running in the full light it shows a dense vegetation of water-parsnip (*Sium*), speedwell (*Veronica beccabunga*) and bur-reed (*Sparganium*). The freshwater-shrimp (*Gammarus pulex*) is not found within this area, and so the Albæk, which would otherwise seem to be well situated for liberations, must be supposed to be able to nourish but a small number of trout fry. 28th August 1936.

dischargings of polluting matter. The latter group includes several kinds, most of them appearing to originate from housekeepings and from dairies, slaughter yards and potato flour mills; at any rate they were found to play a prominent part in the trout waters examined. If the waste water of the housekeepings is being led to the stream from each seperate house, no great harm will be done; but where there is a cluster of houses from which the waste water without sufficient previous clearing is conducted through a joint drain-pipe to the stream, the latter will easily be overcharged, especially by a slow flow of water and high temperature. The consequence is a consumption of oxygen, a settling of mud and greater or smaller changes of fauna and flora for some distance, and this area, at any rate, will be unfit for salmon and trout to live in. The same is the case with the dairies, which apparently in many cases have deliberately been erected near the upper end of the streams, the total flow of which they will sometimes use in order to discharge it again as highly polluted waste water. In both cases the water polluted contains large quantities of organic matter which is gradually assimilated, and, if there are no poisonous effects of other substances and the pollutions cannot be traced to the very outfall of the stream, we will find that below the polluted area there is another very fertile area, abunding i. a. in gammarids. So one would think that the damage caused by the pollution of the upper area is remedied by the increasing nutritive power of the lower. This may sometimes be the case, but undoubtedly this balance of things is easily disturbed. By heavy showers of rain, for instance, the bottom mud of the upper area may be carried to the lower parts and here destroy the trout fry (by oxygen consumption or poisoning?). In the case of the dairies another danger seems to exist: under certain conditions disinfectants (i. a. calcium hypochlorite, which is very poisonous to fishes) have been or are used in cheese-cellars etc. From former times we know the ruinous effect of the potato flour mills on fish, but for a series of year such mills did not exist. The seven new mills built in 1933 give off very great quantities of waste water, the devastating effects of which are often perceptible several miles below the mill, sometimes even at the very outfall of the stream into the sea. Here, too, the destruction is caused by the contents of organic matter in the waste water (for each mill corresponding to the quantity of organic matter in the sewage of a town of about 26000 inhabitants). If the polluted area is not the upper region of the stream but is situated farther below, the question arises whether the young descending trout can pass through this area without suffering any harm. If the polluted area is void of oxygen of course no passing can take place, but it will rarely be as bad as that; often the polluting waste water will appear principally at certain times of the day (for instance at all small dairies), so that it is possible to pass at other times, or the passing may take place during showers of rain when there is a distinct dilution of the water. However, it remains an open question whether the trout coming from above reacts upon the pollution by returning against the current; theoretic considerations do not clear up the question, and we are in need of an investigation concerning the passing of fishes through the sections polluted. A characteristic kind of pollution takes place when marsh water is pumped into the stream. In the summer of 1927 several tributaries of the Sneum Aa were more or less brownish with marsh water although they used to contain clear water, and some of them were dark brown; in one locality an electric pump discharged great quantities of marsh water into the river. Pumpings distributed over a longer period would scarcely be able to affect the water to such a degree. From Norway and Germany we have records on the noxiousness of drain water from sour areas (9, 10, 16, 17, 31, 32, 35). In this country a corresponding case occurred in the Lysbro Bæk in the summer of 1934: after a long period of draught a shower of rain made a recently drained sour meadow give off water of such an acidity, that the pH was measured to be 3.4 in the Lysbro Bæk the water of which has only a small alkali reserve. The fishes of both the brook and the neighbouring trout pond farm were killed in the course of few hours (11, 26).

The time of liberation is very important — i. e. it is a matter of choosing the right point of time during the development of the fry: the streams themselves seem to be ready to receive the fry at any time. It was formerly believed that food was too scarce in the streams in early spring, but Alm (1) has proved this fear to be groundless because numerous food animals hibernate in the streams as larvae or otherwise. Unlike the fry of roach etc. the youngs of salmon and trout are so large, that they are not forced to begin their feeding with daph-

Figure 9. Møllebæk, a tributary of the Skærum Aa, viewed from Møllebro. For some distance the brook has been cut down rather deep and is hidden under meadowsweet (*Spiræa ulmaria*) and nettle (*Urtica dioeca*), growing on the bank and overhanging the water; this vegetation is now dark green and brownish and stands out clearly against the fresh green of the meadow. In the overshadowed part of the brook there are no water plants, and so the stream is poor in trout food, more particularly because the freshwater-shrimp *(Gammarus pulex)* is lacking in this area. In the foreground where it is open to the light are growing water-flag (*Iris pseudacorus*), water-crowfoot (*Batrachium*), starwort (*Callitriche*) and water-parsnip (*Sium*), and here there are better conditions for the food animals of the trout. 29th August 1936.

Figure 10. Møllebæk. Close view of the overshadowed part shown in Figure 9. Under the cover of meadowsweet and nettle runs a large brook measuring about 1 m. in breadth and 30 cm. in depth and having a rapid flow.
29th August 1936.

niae and copepods, which do not become frequent until the water grows warmer, and which on the whole are of inferior importance in trout streams. So the fry of salmon and trout ought to be liberated as soon as they have reached an adequate size.

The quantity to be liberated should not be chosen fortuitously, but attempts must be made to proportion it to the conditions of the stream.

There are only few statements in the literature as to the quantity of trout fry that ought to be liberated in a stream per unit of length or area. Kurt Smolian (34, p. 91) registers the statements, but mentions only the brown trout, in no way, however, the liberation of sea-trout fry or salmon fry; but no doubt that is of inferior importance in this connexion. According to these statements 1 000—2 000 pieces of tiny fry can be liberated annually per kilometre of a small brook of average quality ("Quellbach", no doubt about 1 m. broad — in this case about 1000 m^2) with gravelly or stony bottom; the rest of his statements concern fry of artificial hatching (about two months old) and older fish. Smolian reports (p. 591) that, according to various authors, a pond without feeding can receive 10 000—100 000 pieces of two-months-old fry per hectar, i. e. 1—10 specimens per m^2. Buschkiel (6) writes that the rule generally applied is to liberate 1 000 pieces of fry per km. of a brook of 1 m. breadth, to raise the number to twice this figure when the stream is 3 m. broad, and to raise further, but on a declining scale, with an increasing breadth, whereas other authors are of opinion that the area of the water should be calculated and the quantity liberated be determined according to a possible growth increase of 50—150 kg. per hectar (p. 166).

In trout farms are often used the so-called "natural ponds", i. e. comparatively large shallow ponds formed by damming up water in a meadow, which can be drained for the depletion of fish. In such ponds trout fry are liberated in order to be fished out as older fish in autumn; no baiting takes place: the trout fry has to live on the animals found in the water or coming into it from the air. According to the statements of the late Smidt Nissen, hatchery proprietor, about 10 pieces of fry are liberated per m^2 in Danish natural ponds, and he adds that so dense a population yields good results only in good summers, and that much more natural food is developed in the ponds than in the streams. This is no doubt true.

The above statements afford some dates to go upon, but still there are many doubtful elements left. In the natural pond the half-yearlings are fished out in autumn, and so the pond must nourish the fish for about six months only (the fish generally kept in these ponds are rainbow-trout). In the brook, however, the fry liberated will possibly remain for a year, perhaps for two, but it also happens that the fry leave for other localities shortly after the liberation: undoubtedly, the clearing of a stream will often make the small trout emigrate before their time. — If fry are to be put out in the same stream every year, the liberations should be limited to such numbers, that the fish continue to live under the same good conditions as regards food animals. — The wastage of the fry, particularly during the first time, is a rather incalculable factor. Natural ponds are free from other species of fish but their stocks are very exposed to the attacks of birds (seagulls, terns) and particularly of water-beetles (*Dytiscus*), perhaps also of diseases on account of the dense population. In watercourses, however, the enemies among the insects are of inferior importance whereas other fishes (eel, perch, pike) and birds (kingfishers) may thin the stock. On account of the heterogeneity of conditions it will be difficult to make experiments of general validity but still they might afford some control of the considerations. A checking, for instance, of the size of half-yearlings in thinner or denser stocks would perhaps give some information; but it should be remembered that even in too dense a population we shall undoubtedly find some rapidly growing individuals (the major part showing a slow growth): trout fry normally show a highly varying growth rate; bad conditions of nutrition will principally affect the inferior part of the fry whereas the better part will thrive comparatively well. — In populating a stream it seems reasonable to aim at good conditions for the fish, so that the young fish emigrating to the sea may be vigorous individuals. If the stocks are too dense, we shall presumably find that only few fish emigrate at an age of one or two years while the rest grow three years old before leaving if they do not prefer to remain for good. In overpopulating a stream we shall no doubt, and not for the benefit of the fishery, raise a stock of slowly growing brown trout. According to Alm (4) the different ages at which the salmon emigrate in northern and southern rivers of Sweden are most probably due to the fact that the fish do not emi-

Figure 11. Øleaa (Bornholm) at Engbro. In the bed of the river there are but few puddles left, one of which is seen. The water in it is muddy and intransparent with a temperature of 23° C. It contains plenty of freshwater-shrimps (*Gammarus pulex*) etc. and many young pike. Trout fry could not thrive here. 7th August 1929.

Figure 12. Rodvigsballe Bæk (tributary of the Nimdrup Bæk, which runs in the valley out of view; Gudenaa area). During the dry period this brook, which has a breadth of 50 cm. and a depth of 5 cm., was barred with a dam in order to provide drinking water for about 50 pieces of cattle. At present no water runs through the two drain-pipes in the dam, so that the bed below is dry. In the stone-drain to the left young trout were found dead. Liberations still advisable because the upper part of the brook is not damaged by the damming. 22nd July 1932.

grate until they have reached a certain size (generally 12—15 cm.) and that this size is attained at a higher age in the rivers of the north where the food is poorer (and the annual period of feeding perhaps shorter).

According to my considerations the watercourses may in practice be divided into four groups of quality:

1) unsuitable for the liberation of salmon and trout fry (too shallow (Figs. 7 & 11), too much regulated (Fig. 18), too stagnant, bottom too soft (Figs. 14 & 17), polluted, too large (Figs. 15 & 16). Older fish may be liberated in part of these waters.
2) usable but not good.
3) suitable.
4) pre-eminent.

This characteristic may be based on an estimate of the stream and as far without any regard to the possibility of other circumstances outside the area in question influencing the liberation — for instance without considering the possibility that the descending fish will have to pass through lakes with many pike or through turbines. For practical reasons the classification must be based on estimates of seperate points: it would be better to follow the whole stream, but such a procedure is impracticable as regards both time and economy, and so we shall have to content ourselves with inspections of the stream in an adequate number of localities, which will generally mean places in which it is crossed by roads. When the stream has been classified, which takes place on the spot simultaneously with a recording of further particulars, we also take notes of breadth and depth of the stream. This is often rather difficult, particularly in very small streams with breadths varying from 10 to 100 cm., the depth at the same time ranging between 10 and 1 cm., perhaps with "pools" of 50 cm. depth immediately beside. But we only want to get a reasonable figure; we may not measure the breadth of the bed, which corresponds to the largest flow of water, but only the breadth of the water body present at the moment. And here it will be an advantage to carry out the inspection at a time when the flow of water is comparatively slow, in this country mostly in late summer. Various streams which may seem to be suitable at the time of liberation (March-April) will be dry later in the year (Figs. 7 & 11), and even if part of the fry manage to get farther down the stream, they will here come to areas which have already received their calculated quantity of fry and will therefore presumably be overpopulated. In other words the inspections should be carried out at the most infavourable time of the year.

By the subsequent examination of the written notes the streams are divided into areas the dimension and quality of which may be supposed to correspond to conditions found in the localities examined inside the area. If no tributaries are found, the stream may maintain its character for a long distance; but on the other hand wells (not to be seen on the map) in adding large quantities of water to the stream may change its character to a considerable degree. Here, too, a judicious review should be taken for a basis, including i. a. the fall of the stream. A stream of convenient breadth and depth emerging from a valley with a distinct fall and entering a broad meadow (as do many tributaries of larger brooks) will of course become much too large for trout fry. The individual areas thus plotted on the survey are measured by means of the curvimeter; the length of each interval together with its breadth (according to the random measurings) are taken down and the area is calculated in square metres. If the interval is suitable for liberation, we reckon 1 young trout per sq. m. If it is usable although not very good, we reckon $^1/_2$, and in the case of a pre-eminent interval 2 pieces of fry per sq. m. A simple calculation will show how many specimens of fry should be liberated inside each area.

The figures found in this way are much lower than was originally expected. Previous liberations of fry have always included much higher numbers, but this does not matter for it was nearly always because so heavy quantities were available. E. M. Poulsen (27) has already pointed to the fact that the watercourses of Bornholm seem to be overpopulated because the catches of trout, which had been rising with the increasing liberation of fry, did not rise further when the liberations were extended. It may be disputed whether the scale applied: $^1/_2$, 1, 2 is the rigth one; I consider it likely to yield the best results under the conditions of this country. I have formerly used another scale: 1, $2^1/_2$, 5; but I now think that it produces too dense a stock if liberations are carried out annually whereas it would answer the purpose if fry were put out every second year or in larger intervals. In practice, however,

Figure 13. Faarbæk at Silkeborg, in the background Vejlsø. The brook has a clear sandy bottom an offers no shelter for trout fry. 21st June 1920.

Figure 14. Ramløse Aa. Behind the tree the brook falls into the Arresø amid a dense vegetation of reed. In the foreground brandy-bottles (*Nuphar luteum*) are growing. The bottom is soft and unfit for trout fry. 13th June 1921.

the fry to be liberated in the individual localities of the stream will hardly ever be subjected to an actual counting: the whole quantity is measured out in pails the contents of which in specimens are known approximately, but the final distribution to the individual localities is to a high degree a matter of estimate because a minute counting would hurt the fry and take too long time. If we now imagine a stream in which conditions are suitable for the liberation of one young trout per sq. m. but no more, there will in autumn be left for instance 1 vigorous half-yearling per 10 sq. m. If, instead of 1, 2 specimens of fry were put out per sq. m. of the same locality, we would find not 2 vigorous half-yearlings (because food would be insufficient) but either 1 or for instance 2 of inferior size per 10 sq. m. in autumn. If we take a stream in which conditions are suitable for the liberation of 2 specimens of trout fry per sq. m., so that such a liberation would give 2 vigorous parr per 10 sq. m., a comparatively thin stock of only 1 young per sq. m. would of course give a smaller number of half-yearlings, but the latter would be particularly vigorous. So it seem that we should rather populate an area somewhat too thinly, which is cheaper and gives particularly vigorous half-yearlings, than too densely, which is more expensive and easily results in weak half-yearlings, which perhaps do not even emigrate. Alm emphasizes (4) that the emigration to some degree depends on the length of the fish and that slowly growing young fish will emigrate at a higher age than rapidly growing individuals. He also shows that to a long stay (2—5 years) in the rivers of the north of Sweden corresponds a short stay in the sea, so that these rivers are ascended by comparatively small salmon; most probably this rule is of more extensive validity, so that it is of economic importance to make the youngs of salmon (and undoubtedly those of trout) terminate their stay in fresh water as soon as possible in order that they may spend a longer time in the sea before their first ascent. The best thing is of course to utilize the nutritive power of the stream by the correct numerical strength of the stock liberated.

So we see that a careful distribution of the fry is of paramount importance. If a stream is able to feed 100 000 specimens of trout fry by a correct distribution, so that they develop into 10 000 good half-yearlings, we will get a much inferior result if one half of the same stream is left unemployed and the other half gets twice the number it ought to have. So the thing to aim at is a proper utilization of all suitable parts of the stream.

This will perhaps be considered somewhat exaggerated because the fish themselves are able to spread. So they are to some degree, but it should be remembered that we have to do with fry which will have to grow to an age of some months before they are able to cross even inconsiderable obstructions, of which Danish trout waters generally contain many. In the upper parts, for instance, which make up the best habitat for the fry, there will often be many weirs put up for the purpose of watering the meadows, indeed the water is often stemmed simply by means of a few sods (Fig. 12), an obstruction which is sufficient to bar the passage of a young trout in an upward direction. If a brooklet is led under a road through a pipe, the lower end of the pipe often opens out above the level of the water; even if the trout are able to jump to the pipe, it is uncertain whether they are able to force their way through the long pipe against the rapid current. Also for such reasons the fry should from the first be distributed in such a way, that all good areas are utilized, and if an overpopulating takes place, it should be found in the upper regions of the stream, from which the fry may spread in a downward direction, rather than in the areas farther below, from which they cannot work their way upwards until they are some months old. There is hardly any doubt that good conditions of nutrition during the first few months will increase the chances of the fish surviving the difficult years of young age.

For the sake of completeness it is mentioned that in certain streams or parts of them there may be so good a stock of brown trout or so easy an access for salmon and sea-trout to spawn, that a liberation on fry is unreasonable or even damaging. At present, however, we may in this country unfortunately discount the thought of a natural propagation in our calculations of the quantities to be liberated, as soon as we have passed the first obstruction for the ascent on our way from the sea. It should always be kept in mind that liberations will turn out to be most profitable in areas which for some reason get no fry in a natural way. So it must be a leading rule that liberations should principally take place as far up the stream as possible; but this rule also holds good for another reason, for we saw above that the fry during the first few months are unable

Figure 15. Skærum Aa, a tributary of the Elling Aa, viewed from Skærum Bro. The stream is about 3 m. broad and 0.5 m. deep and has a rapid flow. It is not cleared and therefore contains much vegetation, especially *Sparganium*, both erect and floating leaves, and *Potamogeton alpinus*. Unsuited for the liberation of trout fry.
28th August 1936.

Figure 16. Kongeaaen at Lille Anst. Flowering water crowfoot (*Batrachium*) in tongues from the banks; also a little water-thyme (*Elodea*) is growing here. The stream is too large for trout fry. 18th June 1927.

to pass even rather small obstacles in an upward direction whereas they spread easily down the river.

But it does not suffice that a proper number, say about 10 % of the fry liberated grow up to be vigorous smolt. It is equally necessary that these smolt, or at any rate a fair portion of them, are able to reach the sea safe and sound. There are obstructions enough even though some of them may have been overrated.

In some cases the fishing of boys with hook, catcher or other gears may do some harm to the young fish, which are quite unfit for human food.

Pollutions are hardly very dangerous because liberations in areas showing a permanent pollution will at first be omitted, and destructions of the stock through an acute poisoning are not very frequent in this country.The descending young fish will perhaps have to overcome greater difficulties in passing through a polluted interval of the river (cp. p. 13), but so far we hardly possess any positive information on this matter.

It is very likely that part of the young salmon and trout will become the prey of rapacious fish on their way towards the sea, and it may be supposed that the passage through large lakes with pike and perch is particularly risky; but also this possibility is unsufficiently known to us, and if the descending fish pass rapidly through the lakes, the danger is perhaps not very great. But a greater or smaller part of the trout do not pass rapidly: on the contrary, they stay in the lakes where they may develop into lake-trout. These fish are turned to account although not in way intended, for it is not the state (the free fishing in the sea) or a large indefinite group of persons (fishing for ascending trout in the streams), but the comparatively few part-owners of the lakes that profit by these fish. However, only few per cent. of the descending trout will probably stop in the lakes.

During their emigration or perhaps even previous to that the young salmon and trout will easily get into the irrigation channels, and as long as the latter are in use no great harm will be done. But when the watering ceases a large quantity of small fish will in many cases be pent up in the channels where they perish at once or in the course of some time. This is undoubtedly the most serious danger impending the stocks of salmon and trout in many Danish streams. It may be counteracted by rather simple technical arrangements, but unfortunately most part-owners are not very interested in the matter. However, if we manage to improve the stock of fish in the stream, the interest of the part-owners in the fishery will rise, for it is the mismanagement of the fishery that has led to the disinterestedness of many fishery proprietors. Under the present conditions an attempt at making it obligatory to place gratings in front of the entering channel or to construct collecting cellars for the fish at the draining of the channel or at making other arrangements would only raise the opposition of the farmers; if it is possible in practice to convince them of the utility of the liberations and the harmfulness of the irrigation in its present form, it will undoubtedly be easier to reach satisfactory results. The most difficult group to convince will be the part-owners of the upper regions of the stream, to which localities the ascending fish will never make their way: these people will only show an interest in the liberation if part of the fish remain as brown trout.

The dangers of the irrigation are hardly realized outside the circle of experts whereas the public is apt to overestimate the danger arising from the utilization of the flow of water in the generating stations. The old-fashioned water-wheels, rapidly decreasing in number, hardly constitute any obstruction at all to the descending fish. As far as the turbines are concerned things are somewhat different, but experiments carried out abroad by Alm (2), Kreitmann (19), Lundbeck (20) and Schmassmann (33) as well as in this country by the Biological Station (22) have shown that most of the young fish descending are able to pass safely through turbines of the ordinary types when dimensions are not too small.

Another serious obstacle to the descent are trout pond farms in which all the water is led into the feeding channel, if the latter has no free discharge into the stream.

We do not know how much harm is done to the young descending fish by eel-traps and eel-pots, but undoubtedly this depends highly on local conditions. If the young fish descend principally by night, a thing which is as far unknown to us, they will avoid some turbines, especially the smaller and more dangerous ones which use to be stopped and allow the water to pass freely at night, but on the other hand many of the fish will then get into the eel-

Figure 17. Bovrup Bæk, South Jutland. The trout-trap at Nedre Blaakrog. The trap has been hoisted up because it is outside the catching time, and also the gratings have been taken out. The brook comes from the left and passes to the right under the road. The stream is here unfit for the liberation of fry (too deep, too slow flow and too soft bottom). 3rd August 1932.

Figure 18. Skjerne Aa (North Falstria) at the crossing of the road east of Gundslev. The stream has been regulated and cut down by 1 m. It is nearly stagnant and offers no shelter whatever. 18th June 1929.

traps. The descent takes place principally between April and June and not nearly all eel-traps are being put out during this period. At the outfalls of lakes eel-traps are generally put out also in spring for the purpose of catching the silver eel that could not find their way out in autumn on account of the slow flow and the shallow water. In streams and in lakes with ample flow of water are rarely put out in spring and thus do not hinder the descent of the young fish. If the eel-traps are provided with a collecting contrivance in the back-water for the eel, the young fish will possibly end here, too, so that they may be re-liberated in an uninjured condition (Otterstrøm, 24), and there is also a possibility that the bars of the trap are placed so wide apart, that the smolt are able to pass. But in many localities part of the young fish will unfortunately remain in the eel-trap, above the level of the back-water, and will perish there. Another danger impending are the eel-pots whether they be put out in the streams or off the mouths of the latter or on the open coast. It is a well-known fact that many young trout are caught in eel-pots (or eel pound-nets) in the Nissum Fjord. In many cases young fish caught in weels or pound-nets might successfully be liberated during the act of emptying, but they will often be bruised among other fish or by rough handling; among the small fish thus re-liberated those which cannot at once make for the bottom will be preyed upon extensively by the sea-gulls and terns appearing round the boat.

However, it would not do to put off the liberation of fry until such dangers have been removed: in this case we should get no further. The liberation should be omitted only where it is quite certain that a very large portion of the fry or young fish will perish unless conditions are previously improved.

At last a practical plan of liberation is worked out. The places of liberation are given serial numbers, also to be marked down on the map; for each number is stated how many specimens of fry should be liberated there, and finally proposals may be made as to the route to be followed, so that the liberations are carried out quickly and in such a way, that the largest portions are liberated first of all, thus rapidly decreasing the risks of the transport.

In some cases the liberation is carried out by persons who are acquainted with the localities and may themselves choose the oppurtune route. It would seem preferable to let the persons interested in the liberation transport the fry in their own cars: in this way the rather high freightage is spared. As an instance may be mentioned that the 106 liberation localities of the river Storaaen are worked in one day: the Fishermens' Association of Holstebro and District, which receives a Government grant for the liberation of fry, undertakes the distribution by letting 8 members, each with his car, come to the hatchery at an appointed time, and here the fry are handed over to them under the supervision of a Fishery Assistant.

Liberations carried out on the principles mentioned above will in many respects differ from the usual procedure, but they will most likely be much more efficient. Up to now very great portions of the fry have undoubtedly been liberated in streams of too large a size where they have perished, but furthermore the numbers liberated have undoubtedly been too large as compared to the nutritive power of the watercourse, and the distributing of the fry has been unsatisfactory.

Up to now liberations have been planned by the Biological Station for the following water areas: Tværsted Aa and Flodbæk, Storaaen, Tim Aa, Sneum Aa, Kongeaaen, Brede Aa, Vidaa, Bovrup Bæk, Gudenaa, Lindenborg Aa, Halkjær Aa, Elling Aa and Knasborg Aa, and more plans are being prepared (Uggerby Aa, Skjern Aa and Varde Aa).

As an instance of the application of the principles described above the following brings a review of the plan worked out for liberations in the river Gudenaa, with some comments respecting it.

In the present century the fishery conditions of the river Gudenaa, more particularly its stock of salmon and trout, have been described in a series of papers by A. C. Johansen, J. Chr. L. Løfting, C. V. Otterstrøm and E. M. Poulsen; besides other publications contain many data concerning the fishery of the place. In no other Danish watercourse past and present conditions are so well-known to us. In consequence of a number of circumstances of the usual kind (dammings, pollutions, regulations, too

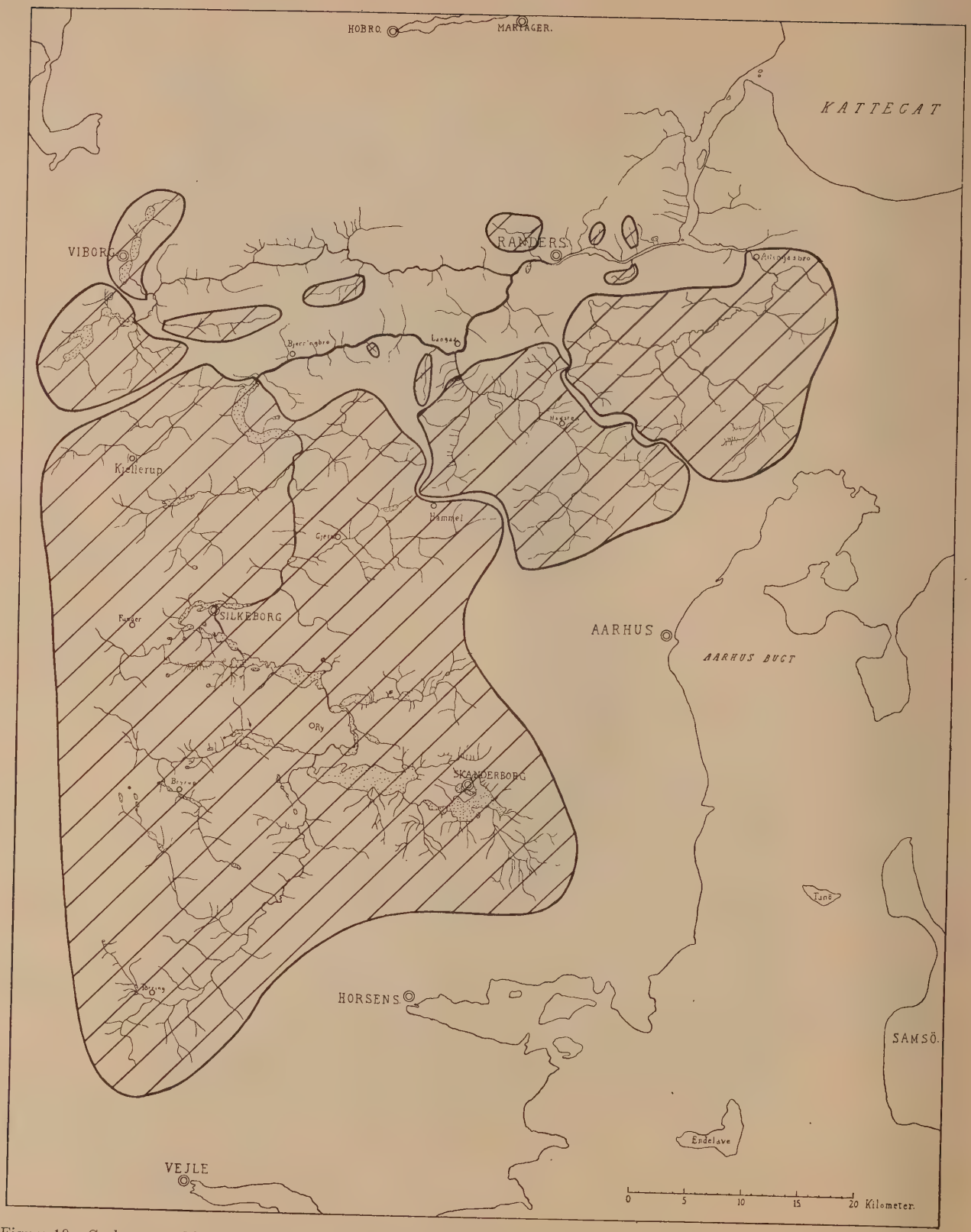

Figure 19. Gudenaaen. The hatched areas are inaccessible for salmon and sea-trout either on account of pollution, which cannot be passed during the period of ascent, or on account of dammings. The accessible area left is of little value as spawning place.

great intensity of the lawful fishery—besides the illegal one — etc.) the stock of trout has decreased and the salmon have disappeared completely. However, there seems to be great possibilities of improving the stock of trout and of creating another stock of salmon because great parts of the area are still exellent nursery grounds for young fish although at present they are inaccessible to the breeding fish. Much could be done by putting up new fish passes and improving the two passes already existing (Tange and Silkeborg); but besides this a well-organized liberation of fry (and, possibly, of older fish) would bring about a rich descent of young fish which, if they could safely pass down the river and out through the Randers Fjord, would most probably soon make themselves felt in the fishery yields of re-entering fish.

According to the examination of the Gudenaa area carried out by the Biological Station with valuations of more than 1 000 localities of the individual reaches of the streams and their adaptability for the purpose of sheltering fry of salmon and trout, and on the basis of the principles propunded above it has been calculated that a little less than 400 000 specimens of fry might be liberated annually (or about 965 000 specimens if liberations (according to Scale 2) were effected every second year). On the map Figure 21 are shown 386 localities of intended liberation.

The interference of man throughout the times with the Gudenaa area as a salmon and trout water appears to some degree from the maps Figs. 19 & 20.

The map of Figure 19 shows how small a part of the area is now accessible to the ascending trout and salmon. The localities now accessible are of quite inferior value as spawning places (vide infra). Of natural obstructions there are none, and in former times the ascending fish must have been able to advance to the sources of the Gudenaa if the vegetation was not too dense; but already in the early middle ages many water-mills were undoubtedly built here, to begin with on the lesser streams only. But even when it came within the faculty of man to dam the large streams, so much free water was presumably let through, that the fish could easily pass. Apparently, it was not until the last century that the weirs became a serious obstacle to the advance of the fish. However, a fact originally damaging the stocks of fish to a high degree was the easiness of access to the inconsiderate fishing carried out in fish-weirs and at the mills; in this respect the regulation of the fishery through fisheries' acts means a great progress indeed.

The river Gudenaa and its tributaries are divided into a great number of small sections by the numerous water-mills and generating stations; most of these are difficult, many of them impossible for the ascending fish to pass. Further there are some irrigation weirs, which, however, are generally out of use during the time of ascent whereas various other kinds of obstructions are active also during this period. The total of such dams etc. amounts to more than 100. Of course they play the greatest part when barring the main stream.

Many areas have been spoiled by pollution and cannot be used for liberations. In 5 cases the ranges above the polluted area are good nursery grounds, but the pollution is so intense, that the young fish will hardly be able to pass, and so liberations are of no interest. In a few cases the pollution is but seasonal: the pollution from the potato flour mill at Auning prohibits the ascent from about 1st October, but not the descent of the young fish, which takes place at a time when the mill is not running. Above this pollution an advantageous liberation might be carried out.

Among the turbines of the Gudenaa area those of the main stream are of course of principal importance as far as the liberations are concerned. The Biological Station has carried out experiments with 3 of them (cp. p. 21); also some other turbines must be passed by many descending fish. 2 of about 30 turbine stations of the area must be considered so damaging in their effects on the fish, that a liberation (except of brown trout) above this place should be totally omitted (cp. the map, Fig. 20).

Two trout pond farms use the whole water flow of the brook leaving no free passage whatever. In one place a brooklet is barred by means of a weir with a flood-gate, thus forming a trout pond with no passage (cp. the map, Fig. 20).

The areas mentioned above have been omitted in the plan of liberation whereas two other localities found to be barred have been included assuming that the obstacles will be done away with. One of them was a brook that had been barred with an illegal weel. The other was a larger brook which was barred by an eel-trap that captured all young fish descending (fry is put out on private initiative); they were put out again but above the eel-trap.

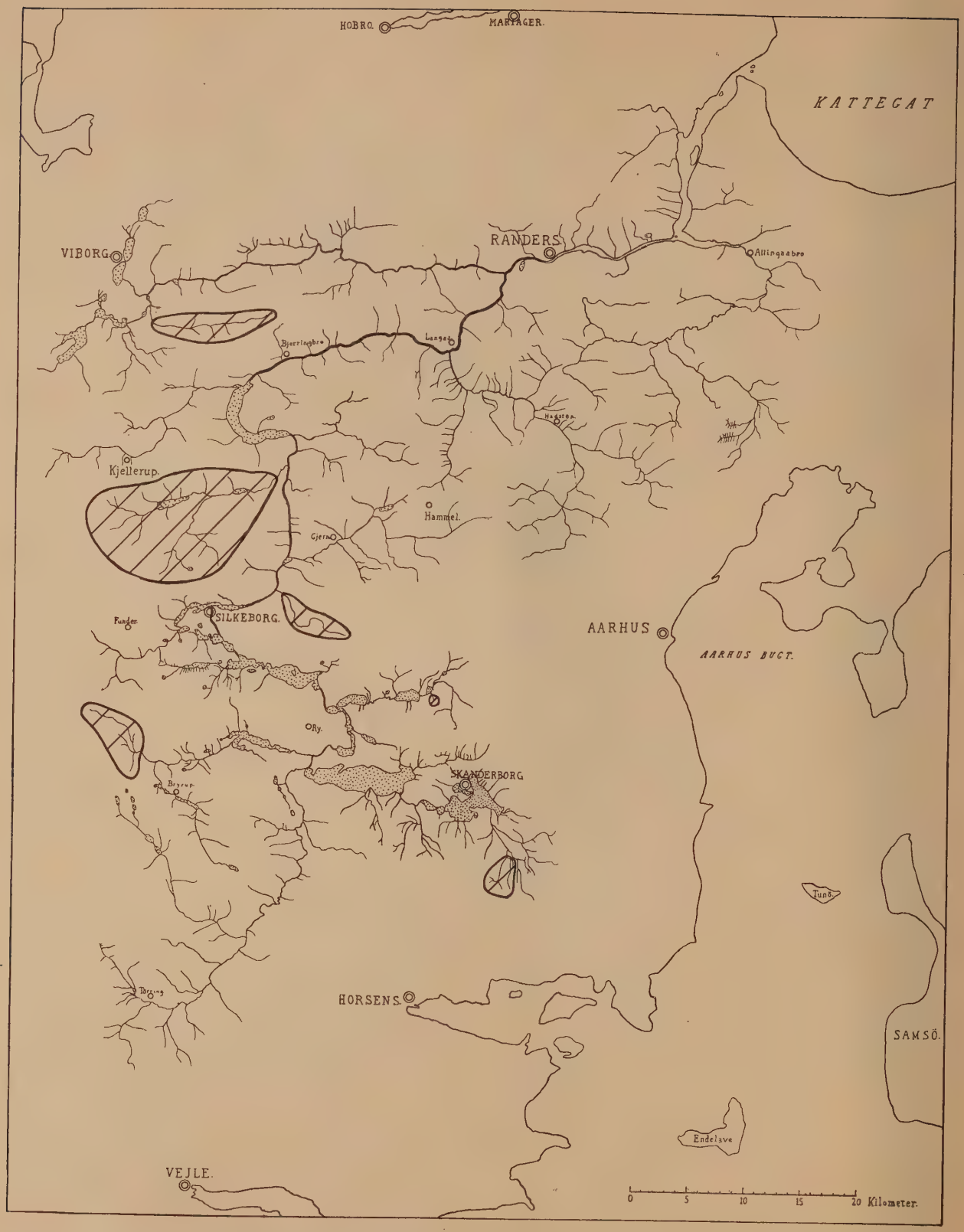

Figure 20. Gudenaaen. Inside the hatched areas liberations of salmon or trout are unadvisable unless the conditions of descent are improved. Good stocks of brown trout might possibly be formed here, but this falls outside the interests of the public.

Irrigation works are comparatively rare along the Gudenaa; the existing ones are of small extent and will not incommode the stock of fish very much.

E. M. Poulsen (28) discusses the problem of the quantities that should be liberated in the Gudenaa area. Basing on some calculations from four watercourses of Bornholm he arrives at the result that the liberation in the Gudenaa should be highly increased: the author wishes 2 million pieces of fry to be liberated annually, but adds that so large quantities of fry should not be put out until the fish pass at Tange has been altered; till then the liberations should be confined to 1—1.5 million specimens to be distributed between the Nørreaa, Alling Aa (to the Grund Fjord), and tributaries of the Gudenaa below Tange. But it is no purpose of the fish pass at Tange to lead the young descending fish past the generating station. Very few fish passes are intended to do such a thing, and a problem of this kind can only be solved if special contrivances make it possible for the descending fish to find the upper mouth of the pass. At Tange it is not even very necessary for the young salmon and trout to descend by the fish pass: experiments carried out in 1932 by the Biological Station (22) seem to show that only few per cent. of the rainbow-trouts (measuring 10—15 and 15—20 cm.) that were sent through the turbines were spoilt by them. It would be illogical to refrain from liberations in the part of the Gudenaa area that is situated above the Tange Generating Station; the consequence of Poulsen's view is that fry should nowhere be put out above turbines and that we should content ourselves with those reaches of the water courses that are accessible to the ascending fish. But the very advantage of the liberation is that areas, though they are inaccessible to the spawning fish, will nevertheless become nursery grounds of young fish, and so there is any reason to put out fry above the various obstructions of ascent while there is less reason to put out fry in areas within the reach of the ascending fish, i. e. places in which a natural breeding may take place.

The streams (the Nørreaa, Alling Aa (to the Grund Fjord) and tributaries of the Gudenaa below Tange) in which E. M. Poulsen proposes to put out 1—1.5 million pieces of fry are represented by a quantity of only 90 000 specimens in the liberation plan worked out by the present author, and this liberation seems to be of inferior importance since the ascending fish themselves may spawn in some localities. However, in the part of the Gudenaa area in which Poulsen (after the alteration of the fish pass) will put out only 0.5 million specimens there is room for about 300 000 individuals according to the liberation plan. Here the disconformity is not so great with regard to figures as to other circumstances. The present author is of opinion that these areas should primarily be considered in the liberations.

Other turbines are worse than those of the Tange Station. But if the fisheries would have to wait for the industry to put up more modern and harmless turbines or the invention of more efficient fish passes before fry of trout and salmon are put out in the said areas, many years would be lost, and we should fail to raise and support the interest in the fishery which is in fact necessary for the purpose of maintaining a proper state of the watercourses as far as the fisheries are concerned. Only where the descent is impossible or very dangerous to the young fish (through very polluted areas and particularly dangerous turbines) the liberations should on principle include only brown trout, many of which will presumably stay here — but in such a liberation only local interests are involved, and it is no matter of the public. So these areas have not been included in the plan of liberation.

E. M. Poulsen has drawn graphs representing firstly the catches of sea-trout in the Randers Fjord and the lower part of the river Gudenaa in the years between 1913 and 1934 and secondly the quantities of liberated fry influencing the catches of the year in question, but found no good correlation. But he still considers it possible that the liberation may have influenced the catch yields in a favourable way. The liberation may, and this seems probable to him, have been of so small extent as compared to the fry appearing in a natural way, that it could not balance the annual variations of the latter. However, we may presumably suppose a fairly constant extent of the natural breeding throughout these years to be a condition of the congruence between the two graphs. Now Poulsen (in his Figure 2) gives a map showing the principal spawning places of the sea-trout; it appears from the text that the map is supposed to cover conditions before 1920 when the Tange Generating Station did not yet bar the access to the spawning places above. If these spawning places are deducted, however, some are left according to the map and

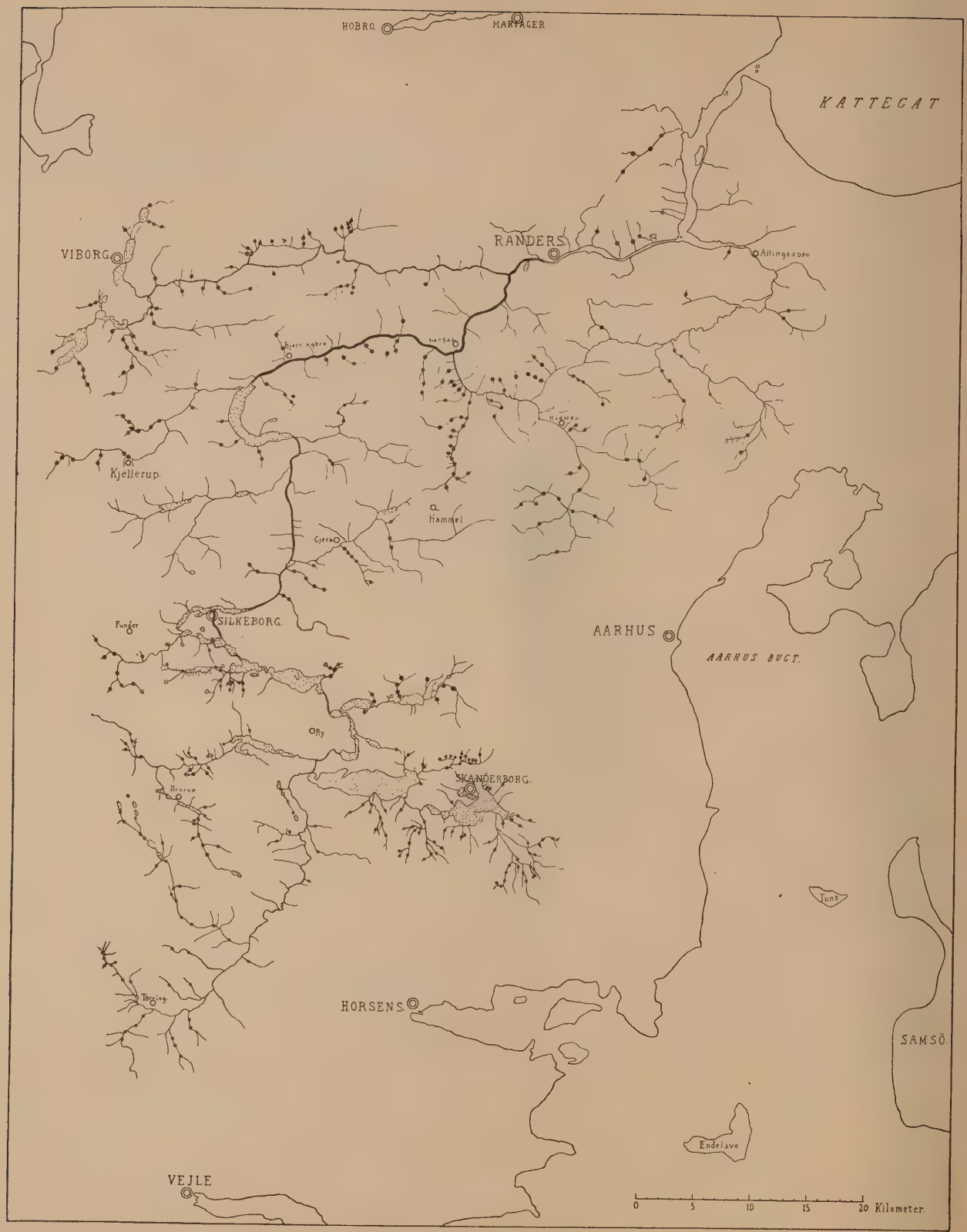

Figure 21. Gudenaaen. The 386 places of liberation proposed in the plan of liberation.

the text, and an examination show us that the latter group includes the following areas:

1) the Gudenaa between Bjerringbro and Tange.
2) the Nørreaa below Rindsholm.
3) the Rind Bæk
4) the Middelhede Bæk } tributaries of the Nørreaa.
5) the Grundel Bæk
6) the Rosenholm Aa } tributaries of the Alling Aa
7) the Skader Aa } (Grund Fjord).

ad 1) The Gudenaa below Tange is in no way uninfluenced by the erection of the generating station. Firstly, the dredging operations have undoubtedly long ago removed the old banks of gravel on which the fish were spawning, and they are now culminating in the large dredging from the generating station down to Randers. Secondly, the flow of water is now and then so irregular, that it may easily bear upon the spawning places if they are still used. During the last few years of drought the generating station has often shut off the flow completely at night, and in the morning the level of the water below is very low. If this has taken place also in winter or early spring, eggs or tiny fry might most probably be injured. However, the gravel banks were most likely removed many years ago.

ad 2) A similar fate has overtaken the spawning places below Rindsholm. The Nørreaa has been dredged, and there is now hardly any possibility of spawning here.

ad 3) The Rind Bæk. To this brook the spawning fish are said to have free access, but in the brook they soon come across obstacles. They are perhaps able to pass the Randrup Mill (about 1 km. up the stream) because much free water is let through, but the Rindsbæk trout pond farm, which is situated about 1 km. above this place, uses the whole flow of water, so that it must be considered out of the question to pass here in an upward direction. So only 2 km. of brook are left below the hatchery.

ad 4) & 5) The Middelhede Bæk and Grundel Bæk join and formerly drained into the Nørreaa below the Rindsholm Mill. Some years ago, however, the lower course was changed, and now the outfall is found immediately above the mill. Consequently, ascending trout cannot get up here, for unfortunately no arrangements (fish pass) were made to this effect nor were any compensatory liberations stipulated. Add to this that another mill (electricity works) at Petershaab a little way up the joint course seems to bar further advance, and that the upper course of the Grundel Bæk (down to Grundel Bridge) is polluted by the Demstrup Dairy; finally the fishery in the tributaries of this brook from the Middelhede Mose has been spoiled by large drainings, and the Middelhede Bæk itself seems to be of very small value.

ad 6) & 7) The Rosenholm Aa and Skader Aa might still seem to offer good possibilities of spawning, but the access of the sea-trout (the salmon did not enter the Alling Aa) to these areas is now impeded for part of the year on account of the pollution caused by the potato flour mill at Auning, which not only makes the small Bjælbæk an open sewer, but defiles the Alling Aa from the outfall of the brook down to the Grund Fjord to such a degree, that no trout is able to enter the river during the campaign of the mill. Some trout will possibly enter before the campaign, but this will hardly be any great number because the campaign generally begins about 1st October. The existence of the mill has been an alternating one. It was running between about 1916 and 1921; then it stopped for some years and started again in 1930. After another stop it started once more in 1933, and since that time it has been running every autumn and winter. So the access of sea-trout to the spawning places of the Rosenholm Aa and Skader Aa has been highly irregular, and in certain years no ascending at all took place, which is confirmed by the fishermen.

The said graphs by E. M. Poulsen representing catches and liberations of fry include the years between 1913 and 1934, and we may therefore suppose that there has been an extremely rapid, but also a very inconstant decrease of the natural breeding by ascending sea-trout, so that there is hardly any possibility of getting a safe basis of calculating the brood of the individual years. Broadly speaking we may perhaps say that a further decrease than the present one of the catches has most likely been hindered by the fact that the want of easily accessible spawning places of the sea-trout has been balanced to some degree, partly by liberations of fry, partly by the apparent spreading of the brown trout over the spawning places that could no more be reached by the sea-trout but had not otherwise been spoiled and by the emigration of part of the young brown trout and their turning into sea-trout. At any rate it seems quite improbable that the stock of sea trout should still be able to maintain a size

worth mention if it were left to recruit exclusively from spawnings going on within the actually remaining and still accessible parts of the spawning places on the map of E. M. Poulsen, to the situation and extent of which places I have no objections provided the map is looked upon as a "historical" map describing conditions about 20 years ago. On the map of Figure 19 in the present paper are marked down the localitities to which the ascending spawners may advance unimpededly. The parts of the main streams that are now accessible are of no value as spawning places, and unfortunately this is also the case with the greater part of the lesser, mostly inconsiderable streams draining into them. It remains to be said that several of these streamlets have been spoiled by pollution or are inaccessible on account of weirs.

On the whole we should be cautious not to rely on figures of liberation as a basis of statistical computations on account of the highly varying value of the liberations. But even if we considered all fry liberated to be of the same quality although of course great differences are found (arising partly from the quality of the mother fish, partly from the run of the hatching — overdue liberations are hardly rare), we have still the locality to consider. The place in which the fry is liberated is of extreme importance, a fact much offended against, particularly by putting out fry in too large parts of the streams. Nor is it in any way indifferent whether many specimens of fry be liberated in one place or they be aptly distributed, and in the same way liberations exceeding the numbers that can find sufficient food will bring about no improvement of the stock. Thus we see that the liberations performed in the course of years cannot safely be compared by merely collating the figures of liberation — not even if the liberations had been carried out in the same localities throughout a series of years; for unfortunately it is not only the spawning places of the sea-trout that were open to access 20 years ago which have been spoiled: vast localities of the liberation area have been ruined or highly deteriorated during these years.

In my opinion a plan for the improvement of the stocks of salmon and trout in the Gudenaa area should aim at the following points.

1) Through improvements in the legislation concerning our watercourses a reasonable guarding of the interests of the fishery is secured, so that the fisheries of the streams are not continually ruined without any compensation.

2) Fry are liberated in such quantities as the various parts of the streams are considered capable of nourishing. A collaboration with the local fishermens' associations would undoubtedly yield the best results.

3) Liberations are pursued principally in the remoter parts of the streams where the natural breeding is smallest. Liberations are carried out pre-eminently in the upper parts of the streams.

4) In all parts of the area where the streams in themselves are well fitted for trout and salmon but too large for the fry, half-yearlings or older fish may be liberated. Also in this case there is only food enough for a certain number of individuals per unit of area, but as the fish are big enough for a rapid migration to other places, we shall hardly run any great risk of overpopulating the area. Furthermore, the older fish are rather expensive, and so an overcrowding will scarcely occur in practice. In my opinion liberations of these fish of artificial breeding should not take place until all possibilities of liberating fry have been turned to account. The reasons for this opinion are not primarily the apparently more favourable results of the liberations of fry (see p. 7), but both in a moral respect and as regards the fishery it will turn out to be the better course if all waters are utilized as far as possible.

5) The conditions of the natural spawning are improved, i. a. by removing the causes of pollution, improving the fish passes and by a gradually increasing consideration to the opening of access for the ascending fish.

6) A provision for the procurement of trout eggs and particularly of salmon eggs by the re-establishment of the fish-weir at Frisenvold. This matter will not be of particular interest until we have managed to re-create a stock of salmon in the Gudenaa.

7) The descending conditions for the young fish are improved by the best means in the individual cases. This point may include turbines that are easier to pass, special fish passes or divertings of descending fish, catching of the fish with

subsequent re-liberation below the obstruction, removing of pollutions, etc.

8) A better observance of the provisions of the Fisheries' Act concerning the minimum size-limit and the close season, which may be reached by extending the supervision but even more so by increasing the interest of the public in the fishery. The close season should no doubt be extended considerably, and perhaps the descending fish ought to be totally protected and the mimimum size-limit to be raised. On account of the difficulty in distinguishing them from each other salmon and sea-trout must be subjected to the same regulations although certain problems will arise here.

9) As far as the salmon are concerned it will be the best thing, as long as only small quantities of fry can be procured, to liberate them in the in the best of the brooks and in small numbers in order to get particularly vigorous young fish. Trout fry should not be liberated together with salmon fry because the former are possibly more voracious than the latter: experiences from the Spjarup trout pond farm show that salmon and trout should not be kept in the same pond because the trout snatch away the food. As long as little fry can be procured the Voel Bæk is recommended as a good place for liberating salmon fry: in four localities it can take a total of 4 000 specimens of fry. When larger quantities of fry are available vaster areas of the streams may be reserved for the salmon. If salmon of artificial breeding can be procured they may for inst. be liberated in the Gudenaa between Silkeborg Langsø and Tange Sø, but undoubtedly they might just as well be put out in a lesser stream (for inst. the Sletaa at Borrissø, Gjernaa or Skaderaa), from which places they might themselves find their way down into the larger streams In putting out salmon we shall scarcely need to pay any regard to the fact that the salmon, when a stock of salmon was still existing inside this area, never entered the rivers Alling Aa (Grund Fjord), Nørreaa or Lilleaa. Undoubtedly, this does not mean that the water of these streams possessed less favourable qualities, but so near the sea the salmon still preserve their full migratory tendencies and therefore wish to face the most rapid current.

10) The proposals of E. M. Poulsen as to restrictions of the weel-fisheries in the Randers Fjord and the lower Gudenaa in April and May, and of the pound-net fisheries on the coast in May and June would most likely influence the stocks of salmon and trout in a favourable way. — By the next revisal of the Fisheries' Act it would seem reasonable to stipulate directions for the construction of eel-traps that would make it possible for the young descending fish to pass with a mimimum risk.

July, 1937.

List of Literature.

1. Alm, Gunnar: Mörrumsåns Lax och Laxöring. En biologisk-faunistisk studie med jämförande undersökningar över faunan i Mörrumsån, Lagan och Dalälven. (Undersökningar rörande Sveriges fiskerier, fiskar och fiskevatten, VII. Linköping 1919).
2. — Fisk och turbiner. (Svensk Fiskeri-tidskrift 1927).
3. — Undersökningar över Laxöringen i Vättern och övre Motala ström. (Undersökningar rörande Sveriges fiskerier, fiskar och fiskevatten, XXX. Stockholm 1929).
4. - Salmon in the Baltic Precincts. (Conseil perm. internat. pour l'explor. de la mer. Rapp. et proc.-verb. des réunions. Vol. XCII. 1934).
5. — Plötsliga temperaturväxlingars inverkan på fiskar. (Kungl. Lantbruksstyrelsen. Meddelanden från Statens undersöknings- och försöksanstalt för sötvattensfisket. Nr. 6. Stockholm 1935).
6. Buschkiel, Alfred: Salmonidenzucht in Mitteleuropa. (Handbuch der Binnenfischerei Mitteleuropas, Bd. IV. Stuttgart 1931).
7. Cornelius, W. O.: Untersuchungen über die Verwertung natürlicher und künstlicher Nahrung durch Regenbogenforellen verschiedenen Alters und unter verschiedenen Bedingungen. (Zeitschrift für Fischerei, XXXI, 1933).
8. Dahl, Knut: Studier og Forsøk over Ørret og Ørretvand. Kristiania 1917.
9. — Massedød blandt ørret ved forgiftning med afløpsvand fra myrer. (Norsk Jæger- og Fisker-Forenings Tidsskrift 1923).
10. Fiskeriinspektørens innberetning om ferskvannsfiskeriene for året 1926. Oslo 1927. (Og senere Beretninger).
11. Hansen, P. Gunder: Et Fiskechok. (Stads- og Havneingeniøren 1937 Nr. 7).
12. Hein, W.: Zur Biologie der Forellenbrut. 1. Versuche über das Nahrungsbedürfnis der Bachforellenbrut im Bruttrog und im künstlichen Brutbett. (Allgemeine Fischerei-Zeitung 1906 Nr. 10—11).
13. — Zur Biologie der Forellenbrut. 6. Zur weiteren Entwicklung der Kiesbettbrut. (Allgemeine Fischerei-Zeitung 1907 Nr. 23).
14. — Investigations into the food requirements of brown trout fry in the hatching trough and in the artificial redd. (Fisheries, Ireland, Sci. Invest., 1905. VIII., (1907)).
15. Hessle, Christian: Gotlands havslaxöring. (Meddelanden från Statens undersöknings- och försöksanstalt för sötvattensfisket. Nr. 7. Stockholm 1935).
16. Huitfeldt-Kaas, H.: Om aarsaken til massedød av laks og ørret i Frafjordelven, Helleelven og Dirdalselven i Ryfylke høsten 1920. (Norsk Jæger- og Fisker-Forenings Tidsskrift 1922).
17. — Atter laksedød i en Ryfylkeelv. (Norsk Jæger- og Fisker-Forenings Tidsskrift 1923).
18. Jacobsen, J. P. and A. C. Johansen: On the causes of the fluctuations in the yield of some of our fisheries. 1. The salmon and sea trout fisheries. (Meddelelser fra Kommissionen for Havundersøgelser. Serie: Fiskeri. Bd. VI. Nr. 5. 1921).
19. Kreitmann, L.: Le franchissement des installations hydro-électriques par les poissons. (Ministère de l'Agriculture, Direction générale des Eaux et Forets. Annales, fascicule 58. Paris 1930).
20. Lundbeck, Johannes: Untersuchungen über die Beschädigung von Fischen, besonders Aale, in den Turbinen des Kraftwerks Friedland (Opr.). (Zeitschrift für Fischerei XXV 1927).
21. Olstad, O.: Ørretvand i Gudbrandsdalen. (Nyt Magazin for Naturvidenskaberne 1925, LXIII. Oslo 1925).
22. Otterstrøm, C. V.: Die Turbinen und die abwärts wandernden jungen Lachse und Forellen I, II, (sowie Aale) III. (Journal du Conseil internat. pour l'exploration de la mer. Vol. VI 1931, Vol. VII 1932, Vol. XI 1936).
23. — Planmæssig Udsætning af Ørredyngel i Vandløb. (Ferskvandsfiskeribladet 1933 Nr. 2—3). — En udvidet Udgave (1935) med tysk Résumé. — Referater i Mitteilungen der Fischereivereine, Westausgabe (1933 Nr. 8—9) og i Zeitschrift für Fischerei (1933).
24. — Aalekisterne og de nedadvandrende Ørreder. (Ferskvandsfiskeribladet 1934 Nr. 12). Særtryk med tysk Résumé.
25. — Om Ferskvands-Tangloppens (Gammarus pulex) Betydning og dens Forekomst Nord for Limfjorden. (Flora og Fauna 1937).
26. — Svovlsyreforgiftning af Vandløb fra udgrøftet Eng. (Ferskvandsfiskeribladet 1938 Nr. 1).
27. Poulsen, Erik M.: Remarks on the Salmon and Sea Trout off the Baltic Coast of Denmark. (Conseil perm. internat. pour l'explor. de la mer. Rapp. et proc.-verb. Vol. XLVIII 1928 p. 111).
28. — Nye Undersøgelser over Gudenaaens Lakse- og Havørredbestand. (Beretning fra Den danske biologiske Station. XL 1935).
29. Schäperclaus, W.: Die natürliche Ernährung der jungen Bachforelle in Teichen. (Zeitschrift für Fischerei XXVI 1928).
30. — Die Drehkrankheit in der Forellenzucht und ihre Bekämpfung. (Zeitschrift für Fischerei XXIX 1931).
31. — Lehrbuch der Teichwirtschaft. Berlin 1933.
32. Schiemenz, Friedrich: Saures Wasser im säuregefährdeten Teichwirtschaften. (Fischerei-Zeitung 1937 Nr. 17).
33. Schmassmann, W.: Versuche über die Beschädigungen von Fischen durch Turbinen. (Schweizerische Fischerei-Zeitung 1928).
34. Smolian, Kurt: Merkbuch der Binnenfischerei, I—II. Berlin 1920.
35. Sunde, S. E.: De sure Sørlandselvene. (Fiskesport 1936).
36. Sømme, Jacob D.: Noen iakttagelser over ørretens gytning og rognens skjebne. (Norsk Jæger- og Fisker-Forenings Tidsskrift 1936 Nr. 4 og 6).
37. White, H. C.: The Food of Salmon Fry in Eastern Canada. (J. Biol. Bd. Can. 2 (5) 1936).

The Dab in the Danish Waters, Investigations on Stock and Growth.

By

ERIK M. POULSEN

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Introduction.

In the Report of the Danish Biological Station for the year 1933[1]) the present author dealt with various biological conditions concerning the stock of dab in the Danish waters and with the changing yield of the dab fishery throughout the years. The intention of the following pages is to give a more detailed account of the growth of the dab and the fluctuations met with in the individual quantities of the year-classes.

On the changes in the yield of the Danish dab fishery.

The yield of the dab fishery (Table 1 and Figures 1 and 2) rose most rapidly during the years between 1920 and 1932; in 1933 and 1934 it diminished somewhat, in order to rise distinctly in 1935 and 1936; in 1920 the total dab fishery amounted to about 800 metric tons only, in 1936, however, to no less than about 4,000 metric tons.

The rise in the yield of the dab fishery was no uniform one in the different waters (cp. Figure 2). In the North Sea the rise was rather insignificant from 1920 to 1934, from about 80 to about 250 tons, but very pronounced in the years 1935 and 1936, from about 200 to about 600 tons; there is reason to believe that this rise is partially due to the decrease of the plaice fishery during the same years and may have led to an increased interest in the dab as compared to previous years. In the Kattegat the catches of dab reached about 1,400—1,500 tons already in 1926—27; a fall in the years 1928—31 was followed by another rise, which in 1935 and 1936 brought the yield to a level with the year 1926. In the Belt Sea the heaviest catches (fully 1,000 tons) occurred in 1931, but they have remained fairly constant since that time. The fact that the dab fishery in the Kattegat and the Belt Sea has mostly maintained this standard during recent years seems to indicate that the dab fishery of these two waters has now reached such a degree of efficiency, that no considerable increase of the yield can be expected under the present conditions of the stock of dab in these waters. In the Baltic Proper the fluctuations in the yield of the dab fishery are most conspicuous. Up to 1928 the annual yield amounted to less than 40 tons and may thus be said to have been wholly unimportant. But in 1929 the yield suddenly rises to 10 times this quantity or a little more than 400 tons; the year 1930 brings another rapid rise to an amount of 750 tons, and the year 1931 even shows a total catch of 840 tons. But then the yield begins to fall: in 1932 it is 750 tons, in 1933 230 tons, and in the three years 1934—36 it averages only 100—150 tons. So we see that in this water the dab fishery yielded heavy catches during the short period between 1929 and 1932. The development of the dab fishery in the Baltic Proper has been parallel to that of the plaice fishery with the exception that the maximum yield of the former occurred 7 years later than that of the latter (cp. Figure 3). When the great fishing of plaice started in the years 1923—24, it was based on an accumulated stock of old, slowly growing plaice. When this stock had been exhausted, the yield again decreased considerably, and since that time the comparatively small years catches have only been subject to such fluctuations as are caused by the changes in the annual supply of fry: 3—4 years after the rich spawning year 1928 we find some rise of the yield. During the rapid decline of the plaice fishery in the

[1]) Erik M. Poulsen: Biology of the Dab in Danish Waters. Rep. Dan. Biol. Stat. XXXVIII, 1933.

years 1927—29 the fishing of flat-fish is apparently continued, but on account of the failing catches of plaice an interest is taken in the dab, and the rising market value leads to heavy landings of this fish. Therefore the yield of the dab fishery shows an extremely rapid rise in the years 1929—31: in 1926—28 the average landings were 28 tons per year, in 1930—32, however, no less than 785 tons, i. e. a rise to about 30 times the former quantity. But the dab fishery, too, was based on an accumulated stock, and therefore a rapid fall of the yield took place within a few years. In the Baltic the dab fishery — as well as the plaice fishery — must now be supposed to rest on the annual supply of fry, and its fluctuations will in future follow the changing extent of this supply.

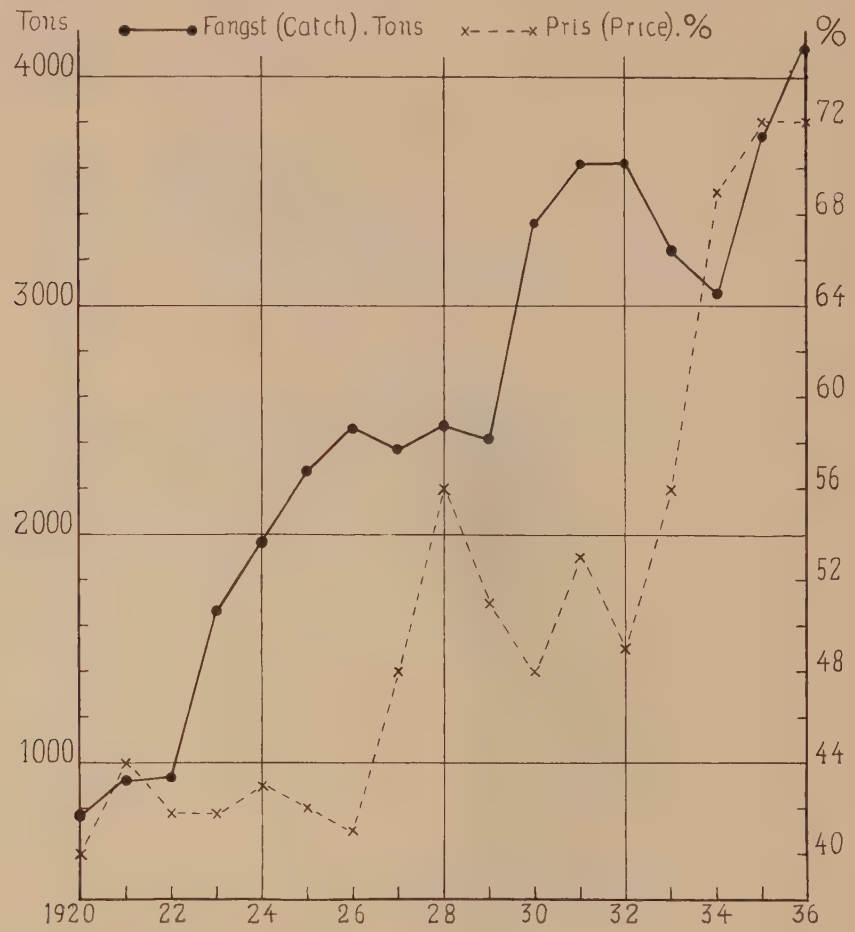

Figure 1. The total yield of the Danish dab fishery and the prices of the dab in % of that of all other species of fish in the years between 1920 and 1936.

On the whole the weight yield of the Danish dab fishery showed a very high rise during the years between 1920 and 1936. But the development is no parallel one in the different waters. In the North Sea a distinct rise does not occur until quite a few years ago (1935—36), possibly in connexion with the decrease of the plaice fishery. In the Kattegat and the Belt Sea the increase of the dab fishery took place already in 1923—28 and was not here followed by any decrease: as the yield of the last ten years, apart from inferior annual fluctuations, has been fairly constant, it must be supposed that a certain balance between the supply of fry and the removal of adult fish now exists in these waters. If no essential changes take place in the fishery or the conditions of the stock of dab, the yield of this fishery must be supposed to be able to maintain its present level for the years to come. In the Baltic Proper the dab fishery experienced a short rise between 1929 and

1932, but now again it is of inferior importance, and there seems to be no real hope of another increase of the yield in this area.

A rise in the weight yield of some species of fish is often caused by an increase of the stock of the fish in question; in this case the rise of the weight yield rising prices in spite of the increasing supply. Between 1920 and 1925, when the prices of fish were generally high, dab were still cheap. However, in 1934—36, when the fish prices were considerably lower, the prices of dab had risen to a much higher level than in 1920—25. This improvement of prices appears

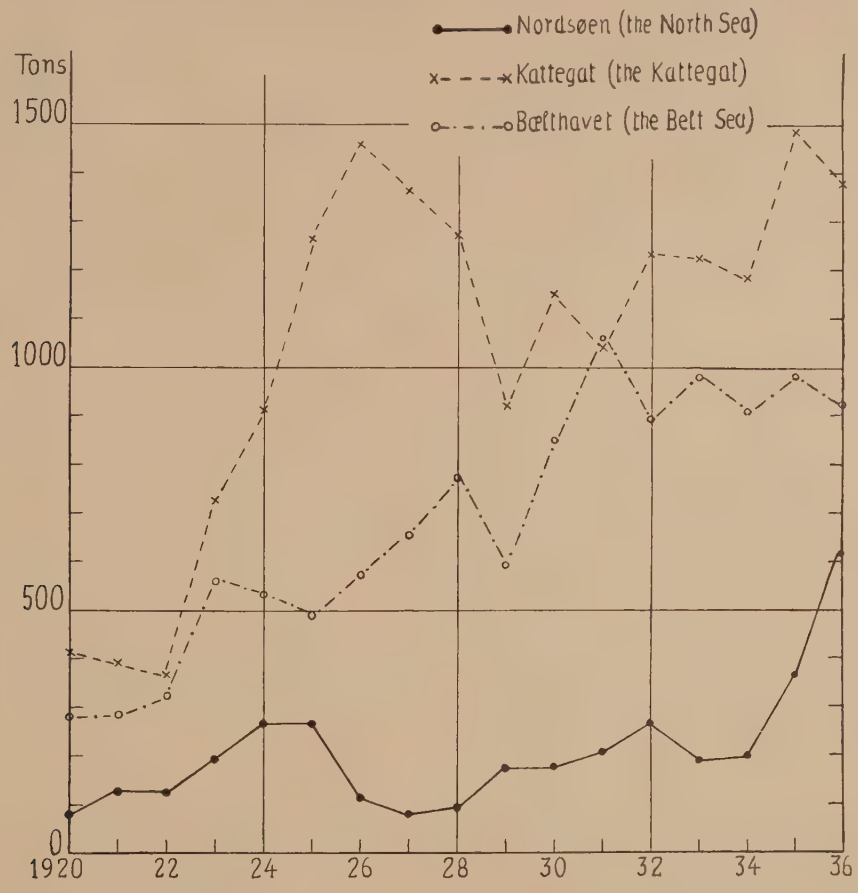

Figure 2. The yield of the Danish dab fishery in the North Sea, the Kattegat, and the Belt Sea in the years between 1920 and 1936.

will mostly be followed by a fall in the market value of the fish. As far as the dab is concerned, however, it is evident that the rise of the yield — which has taken place in widely different waters — is not a consequence of an augmentation of the stock, but has been caused by a rising interest in this species of fish on the part of both fishermen and consumers. This interest is undoubtedly connected with the fact that the partially failing plaice fishery has not been able to meet the demand for this fish. Therefore the rise in the weight yield of the dab fishery was not followed by a depreciation of the dab; on the contrary, the interest taken in this fish has led to constantly distinctly from the items below, stating the average prices in Danish Øre per kg. of all species of fish and of the dab alone during the two periods:

	Dab Øre per kg.	All species of fish Øre per kg.
1920—25	25	58
1934—36	32	45
	+ 7	÷ 13

During this period the price of dab has risen by 7 Øre per kg. whereas that of all kinds of market fish together has fallen by 13 Øre per kg. In the period 1920—25 the value of the dab made up only 42 per

cent. of the mean value of all market fish, but in 1934—36 it ran as high as 71 per cent. These figures are clearly representative of the considerable rise in it was about 220,000 Kr., but in 1935—36 about 1,300,000 Kr. Another expression of the rise we find in the percentage value of the dab fishery as compared

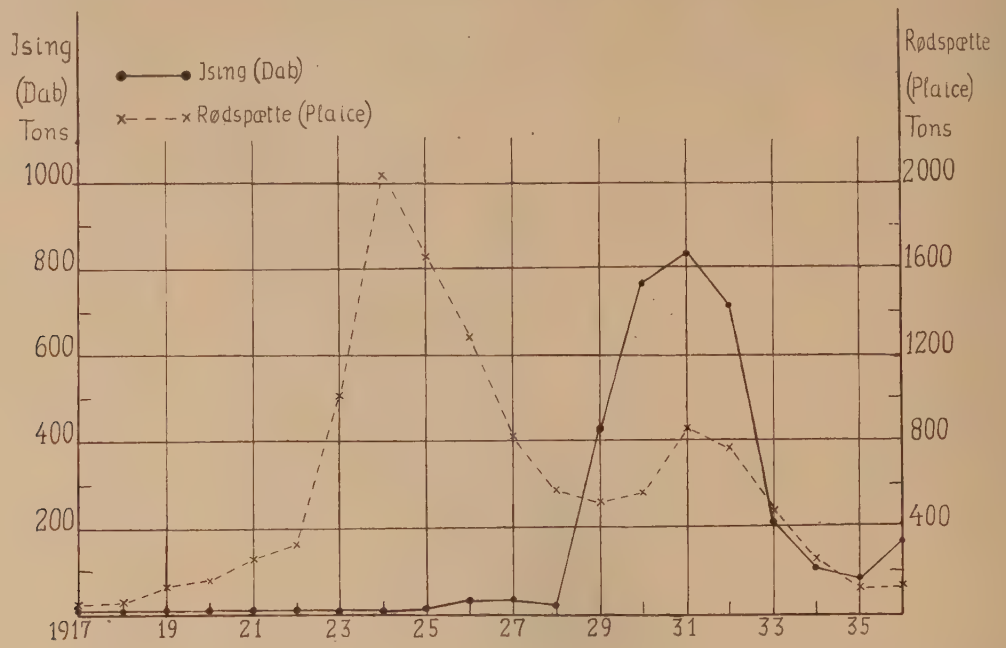

Figure 3. The yield of the Danish dab and plaice fishery in the Baltic Proper in the years between 1917 and 1936.

the value of the dab during the said period. This rise of value also appears from the increasing value of the yield of the dab fishery (cp. Table 1): in 1920—21 to the rest of the fisheries: in 1920 the dab fishery represented only 0.5 per cent. of the value of all our salt water fisheries, in 1936 no less than 3.4 per cent.

Table 1. Yield in tons of the dab fishery in Danish waters.

Year	North Sea[1])	Skage-rak	Katte-gat	The Sound	The Belt Sea	Western Baltic	Baltic proper	All Denmark Yield in		Price per kg. Øre	Mean price for all fishes Øre per kg.	% Value of dab fishery to all Danish fisheries
								Tons	Kroner			
1936.....	616	49	1 377	39	923	235	170	4 101	1 349 227	33	46	3.41
1935.....	365	29	1 487	43	983	158	83	3 772	1 254 349	33	46	3.17
1934.....	194	45	1 185	28	905	125	105	3 046	876 866	29	42	2.32
1933.....	186	67	1 215	40	980	133	204	3 225	725 776	23	41	2.06
1932.....	266	35	1 236	43	897	137	759	3 607	641 093	18	37	1.93
1931.....	201	58	1 045	40	1 057	159	831	3 628	714 124	20	38	2.08
1930.....	172	95	1 150	46	850	135	764	3 371	706 751	21	44	1.74
1929.....	172	114	916	15	592	51	420	2 414	526 216	22	43	1.38
1928.....	97	96	1 267	20	775	39	20	2 479	549 340	22	39	1.50
1927.....	90	12	1 363	28	657	39	31	2 385	460 167	19	40	1.36
1926.....	117	3	1 452	22	577	38	34	2 457	468 812	19	46	1.31
1925.....	262	1	1 252	10	496	15	22	2 283	537 511	24	57	1.21
1924.....	268	0.2	913	22	532	4	9	1 943	550 937	28	65	1.23
1923.....	198	0.2	722	40	560	9	8	1 661	353 423	21	50	1.04
1922.....	120	..	361	14	321	0.1	6	922	206 736	22	53	0.77
1921.....	126	..	396	6	285	0.2	4	907	232 749	26	59	0.65
1920.....	75	..	417	12	282	0.4	3	789	206 261	26	65	0.49

[1]) Only quantities landed i Danish harbours included.

In 1910 the dab was No. 17 among our food fish (lobster and shrimps included). In 1920 it had advanced to No. 12, in 1930 to No. 8, and in 1936, finally, to No. 6. Above the dab with its percentage value of 3.41 we now only find plaice (39.85 per cent.), eel (11.90 per cent.), cod (10.6 per cent.), herring + sprat (9.23 per cent.), and other species of fish (3.56 per cent.).

From March 1934 we have a minimum size-limit for the dab of 25 cm. total length, including all Danish waters. It will therefore be of interest to see whether this minimum size-limit has perceptibly influenced the dab fishery. A look at Table 1 will show that the rise of the weight yield is on the whole uninfluenced by the minimum size-limit. However, the size-limit has possibly brought about a small rise in the price of the dab. Before the introduction of the minimum size-limit in 1934 the price was 29 Øre per kg., in 1935—36 it was 33 Øre, which is a rise of 14 per cent. But during the same period the price per kg. of all sorts of fish together has risen by 10 per cent., and so the rise in the value of the dab is but little higher than that of the other species of fish. At any rate the increase of price that has been caused by the introduction of the minimum size-limit is but small. It will appear from the following that a minimum size-limit is unnecessary from a biological point of view for the maintenance of the stock of dab, and so it should only be retained if it is necessary for reasons of sale or the like; it was shown above that its importance as a price-raising factor has been small.

Fluctuations in the size of the stock of dab during recent years.

In connexion with the rapidly increasing intensity of the dab fishery during the last two decennia it will be of interest to examine whether changes have taken place during the same period in the size of the stock of dab, its age composition, and its conditions of growth.

A comparison between the quantities of dab caught with the otter seine from the "Thor" between 1903 and 1911 and from the "Dana" between 1922 and 1930 throws some light on this question. In the table below (which was published in a more detailed form in the Rep. Dan. Biol. Stat. XXXVIII, 1933) are stated the figures of mean captures per hour in our different waters during the two series of years:

	1903—11			1922—30		
	Number of stat.	Fishing hours	Dab per hour	Number of stat.	Fishing hours	Dab per hour
The North Sea...	122	283	**186**	91	73	**497**
The Skagerak....	78	181	**44**	25	27	**83**
The Kattegat....	156	513	**123**	19	17	**110**
The Belt Sea + the Western Baltic.	8	12	**239**	10	13	**54**
The Baltic Proper	19	31	**114**	30	27	**164**

For the North Sea and the Skagerak the figures distinctly establish the increasing density of the dab population during the time between the two periods. This is connected with the fact that the density of the plaice population in the same waters decreased considerably[1]) during the same period, thus leaving the dab improved conditions of nutrition, and moreover an intenser fishing of dab did not begin until a later point of time (1935—36) than the fishing experiments of the period 1922—30. In the Kattegat, the Belt Sea, and the Western Baltic conditions are quite different, the figures here showing a lower density in the latter than in the former period. This agrees well with the fact that an extensive fishing of dab took place in these waters already between 1922 and 1930, causing a distinct reduction of the accumulated stock. In the Baltic Proper the figures show some rise of the density. But in this water all researches within the period 1922—30 were carried out in 1922—23, and so the figures thus obtained do not tell anything about the degree to which the density of the population was influenced by the large fishing of dab, which did not take place until the years 1929—32. Altogether it appears from the investigations mentioned here, 1° that the thinning of the plaice population of the North Sea has occurred alongside of an increase of the dab population of this water, and 2° that the intense dab fishery in the Kattegat and the Belt Sea has brought about a decreasing density of the dab population of these waters. As far as the Baltic Proper is concerned the

[1]) After the present paper has been committed to print Dr. Aage J. C. Jensen has kindly informed me that the density of the stock of young plaice in the Horns Reef Area has not diminished between the two said periods.

figures show that the population of dab was somewhat denser in 1922—30 than in 1903—11; in this water, however, nearly all investigations within the former period took place in the years 1922—23, that is to say before the starting of the large dab fishery in the Baltic; so the figures tell nothing about the thinning of the dab population that must have been the consequence of this fishery.

However, the extent of this thinning can in part be estimated from the fishing experiments of the Danish Biological Station with the eel-seine in the years 1927—37 (cp. Table 2). In the waters round Bornholm (E. of 14° E.) the results show a marked decrease of the density of the stock. For all depths together the average catch figure for the years 1927—32 was 32 individuals, for the years 1933—37 only 15; it further appears from the figures that the greater depths of water show the most pronounced decrease of density. This is a consequence of the fact that the accumulated stock of older individuals, on which the large fishery was based, mainly lived in rather deep water. In shallower water, the principal inhabitants of which are the younger year-classes and where consequently no accumulated stock can properly be said to exist, the decrease in the number of individuals is much smaller.

According to the table the fluctuations of the quantities are but small in the rest of the waters. For the Skagerak, the Kattegat, and the Western Baltic the numbers of individuals are slightly lower in 1933—37 than in 1927—32, in the Belt Sea and the Sound, however, somewhat higher.

We have seen above that the thinning of the dab populations of the Belt Sea and the Kattegat, which was caused by the intense fishing of dab in the years about 1922—28, does not continue during these late years. This fact appears more clearly from the figures below, which state the numbers of dab caught in the eel-seine per 30 minutes, for each year of the period 1927—37:

Mean figure per 30 min....	1927	1928	1929	1930	1931	1932
The Kattegat	130	125	69	122	83	229
The Belt Sea	126	36	29	73	87	108

Mean figure per 30 min.....	1933	1934	1935	1936	1937
The Kattegat	102	63	93	103	114
The Belt Sea	76	104	109	150	110

As will be seen the annual means are rather variable, in the Kattegat ranging between 63 and

Table 2. Catch of dab in eelseine in the years 1933—37, compared with the catch in the years 1927—32.

Area and depth-zones	1933—37 No. of stat.	1933—37 No. of dab total	1933—37 No. of dab per 1/2 hour	1927—32 No. of dab per 1/2 hour
Skagerak				
1—10 m.	15	283	19	33
11—20 -	14	1 057	76	61
21—40 -	1	361	361	80
41—60 -	3	95	32	62
61—80 -	2	..	0	13
Total...	35	1 796	51	75
Kattegat				
1—10 m.	106	2 362	22	57
11—20 -	58	10 708	185	195
21—40 -	97	11 714	122	118
41—60 -	11	183	17	36
61—80 -	1	31	31	22
Total...	273	24 998	92	119
The Sound				
1—10 m.	..	..	..	15
11—20 -	28	495	17	14
21—40 -	25	663	26	9
Total...	53	1 158	22	12
The Belt Sea				
1—10 m.	16	377	24	18
11—20 -	163	20 030	123	103
21—40 -	117	11 065	95	49
41—60 -	6	260	43	53
Total...	302	31 732	105	76
Western Baltic				
1—10 m.	..	..	..	12
11—20 -	4	103	26	39
21—40 -	16	727	46	49
Total...	20	830	40	43
True Baltic, W. of 14° E.				
1—10 m.	2	2	1	1
11—20 -	22	276	13	14
21—40 -	38	1 536	40	14
41—60 -	1	2	2	50
Total...	63	1 816	29	17
True Baltic E. of 14° E.				
1— 10 m.	6	..	0	1
11— 20 -	7	49	7	7
21— 40 -	36	716	20	42
41— 60 -	12	275	23	35
61— 80 -	2	10	5	27
81—100 -	11	76	7	45
Total...	74	1 126	15	32

229, in the Belt Sea between 29 and 150 individuals per 30 minutes. As regards the Belt Sea the stock seems to have been particularly thin in the years 1928—29. However, the general impression of the whole period is one of an increasing density of the population as will also be seen from the following average figures of dab caught per 30 minutes:

	The Kattegat	The Belt Sea
1927—31 (5 years)	106	70
1932—37 (6 years)	117	126

So there is nothing to indicate a decrease of the dab population in these waters during the last decennium. It might be supposed that the minimum size-limit introduced in March 1934 had brought about some rise in the size of the stock during the last few years, but in comparing the average catch number for the three years 1935—37 with the preceding 3-years periods we find no basis for such a supposition:

	Specimens of dab per 30 minutes			
	1927—28	1929—31	1932—34	1935—37
The Kattegat	128	91	131	103
The Belt Sea	81	63	96	123

In the Belt Sea there is a small rise of the catch figures in the years after the introduction of the minimum size-limit, but in the Kattegat the last few years have brought a decrease of the catch figures. Thus we may say that on the whole the minimum size-limit has not yet caused any perceptible augmentation of the stock. But on the other hand such an increase of the stock will not appear in its full extent until after some years when we get the new year-classes that are being recruited from the stocks of mother fish now under the protection of the minimum size-limit. There is no doubt that the present minimum size-limit (25 cm.) will cause an increase of the dab population in the course of years because a very great part of the spawning dab are protected by this size-limit: the males may be found to be mature already at a length of 7 cm., the females at a length of 9 cm. only. That large quantities of spawning dab of both sexes are protected by the present minimum size-limit further appears from the following figures found by maturity determinations of 3,227 specimens of dab (cp. Erik M. Poulsen, l. c., 1933): In the North Sea the majority of females and males become mature at lengths of 22 and 16 cm., respectively; in the Kattegat the corresponding figures are 16 and 11, in the Belt Sea 14 and 9 cm. So it is most likely that in the course of years the present minimum size-limit will bring about an increase of the dab population in our inner waters, especially in the Belt Sea, where a very dense stock of dab was found before the otter seine fishery started about 1908—10.

Fluctuations of the individual quantities of the year-classes in the waters inside the Skaw.

As mentioned above the minimum size-limit introduced in March 1934 means a very effective protection of the spawning stock of dab, especially in our inner waters; so it would be interesting to look into the question whether particularly large quantities of young dab have appeared during the last few years (1935, 1936, and 1937). For this purpose, however, it will also be necessary to find out how large were the quantities of fry appearing during the years before the introduction of the minimum size-limit. On the basis of the fishing experiments with the eel-seine carried out by the Danish Biological Station we will therefore try to represent the fluctuations of the quantities of fry within the years 1927—37. The individuals of the 0-Gr. of dab (the fry of the year) are so small, that few of them are caught in the eel-seine; so we shall have to estimate the quantity of fry on the basis of the older age groups, more particularly the individual quantities of the I- and II-Groups (1- and 2-year-old dab). We will primarily deal with the Kattegat and the Belt Sea because the most extensive fishing experiments were made in these two waters.

In Table 3 are stated the numbers of individuals of different age groups caught per 30 minutes with the eel-seine in the Kattegat and the Belt Sea in the years between 1927 and 1937. It appears directly from the figures that the quantities of dab of the different year-classes are varying somewhat from year to year and that fairly the same variations are met with in both waters. Figure 4 gives the quantities of I-Gr. individuals caught per 30 minutes in the different years. In the Belt Sea the year-classes 1927, 1928, 1931, and 1932 were poor, the year-classes 1926, 1929, and 1933—36 were rich ones. In the Kattegat poor year-classes appear in 1928, 1930, and

Table 3. No. of dab of various age-groups caught per $^1/_2$ hour in eelseine in the Kattegat and the Belt Sea in the years 1927—1937.

Area	Year	No. of stat.	No. per $^1/_2$ hour of Gr.: 0	I	II	III	IV	V	VI	VII	VIII
Kattegat	1937	28	..	30	38	14	2	0.3	0.1	..	0.02
The Belt Sea	—	44	..	56	30	22	9	2	1	0.1	0.04
Kattegat	1936	21	..	56	61	13	2	0.1	..	0.05	..
The Belt Sea	—	48	..	86	48	24	6	2	0.2	0.1	..
Kattegat	1935	33	..	24	37	7	0.4	..	..	..	..
The Belt Sea	—	56	..	63	34	13	14	2	0.2	..	..
Kattegat	1934	26	..	23	19	15	2	0.1	..	..	..
The Belt Sea	—	27	..	69	11	18	12	2	0.1	..	..
Kattegat	1933	27	..	11	57	46	4	0.4	..	..	..
The Belt Sea	—	29	..	7	35	26	13	2	0.03	..	..
Kattegat	1932	20	..	124	30	9	0.9	0.1	..	..	..
The Belt Sea	—	37	..	29	45	30	4	0.4	0.2	..	..
Kattegat	1931	22	..	12	32	11	0.4	0.05	..	..	..
The Belt Sea	—	38	..	50	32	13	6	2	1	0.3	0.05
Kattegat	1930	..	..	..	..	..	..	..	..	..	..
The Belt Sea	—	23	..	104	12	5	2	0.5	0.2	0.05	..
Kattegat	1929	45	..	27	29	2	0.1	0.02	..	..	..
The Belt Sea	—	29	..	14	9	7	2	1	0.6	..	0.1
Kattegat	1928	2	..	172	77	18	0.5	..	..	..	..
The Belt Sea	—	6	..	14	42	19	4	0.8	..	..	..
Kattegat	1927	18	..	68	63	14	3	0.3	0.1	..	..
The Belt Sea	—	20	..	67	46	24	25	12	5	0.7	0.1

1932—34, comparatively rich ones in 1926, 1931, 1935, and 1936. From the Kattegat we have no observations concerning the occurrence of I-Gr. individuals in the years 1928 and 1930, and so we cannot by this means determine the individual quantities of the 1927 and 1929 year-classes in the Kattegat. But if we also consider the individual quantities of the age groups II, III, and IV, we shall be able to estimate the individual quantities of the said year-classes. The individual quantity of a year-class diminishes with the years, partly because of the natural decrease, partly on account of the fishing and so it is necessary, for the purpose of determining the individual numbers of some year-class on the basis of several age groups, to apply a higher numerical value to the individuals of the older age groups than to those of the I-Group. Therefore the following mean figures (catches per 30 minutes) for the individual age groups of the year-classes have been calculated by means of the material contained in Table 2:

	I-Gr.	II-Gr.	III-Gr.	IV-Gr.
The Kattegat (4 year-cl.)	42	36	20	2
The Belt Sea (8 year-cl.)	44	28	17	8

On the basis of these figures, which represent the reduction of the individual quantity from the I-Gr. through the II- and III-Gr. to the IV-Gr. in the catches with the eel-seine[1]), have been calculated the following figures, by which we shall have to multiply the individual quantities of the II-, III-, and IV-Gr. as found in the fishing experiments, for the purpose of making direct comparisons between these groups and the I-Gr.:

Age-Group	II	III	IV
The Kattegat	× 1.2	× 2.0	× 2.0
The Belt Sea	× 1.6	× 2.6	× 5.5

By this method of calculation we get the following figures, which state the numerical strength of the year-classes on the basis of the individual quantities of the age groups I—IV, caught per 30 minutes:

Year-class	1923	24	25	26	27	28	29
The Kattegat	60	28	38	36	22	22	45
The Belt Sea	138	42	45	41	14	22	76
Both waters	99	35	42	39	18	22	61
Year-class	30	31	32	33	34	35	36
The Kattegat	45	58	22	33	42	51	30
The Belt Sea	64	52	23	89	66	67	56
Both waters	55	55	23	61	54	59	43

So the fluctuations of the numerical strength of the year-classes are rather great, ranging in the Kattegat between 22 and 60, in the Belt Sea be-

[1]) i. e. not in nature.

tween 14 and 138. For sake of perspicuity these figures have been given a graphical form in Figure 5, from which it appears that the year-classes 1927, 1928, and 1932 were poor, while the year-classes 1923, 1929, 1930, and 1933—36 were comparatively

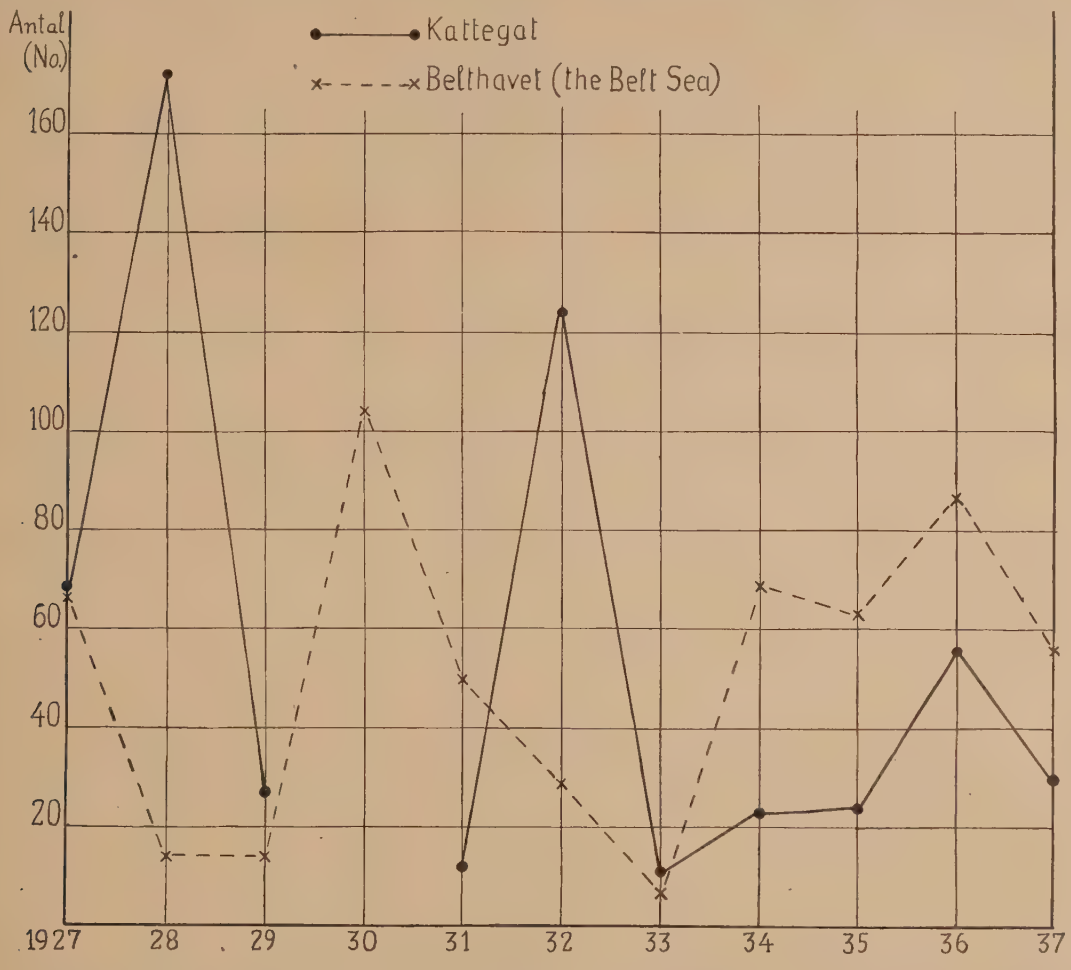

Figure 4. Numbers of individuals of the I-Gr. of dab caught in 30 minutes' hauls with the eel-seine in the Kattegat and the Belt Sea between 1927 and 1937.

rich ones. Broadly speaking we may say of the dab that the years 1924—28 were poor spawning years, but the later years 1929—36 were good ones, and there is nothing to show that the dab population of the waters inside the Skaw should have diminished during the last 10 years. On the contrary, the quantities of fry are apparently more numerous in the years after than in the years before 1929. A minimum size-limit like that introduced in 1934 is unnecessary for the preservation of the stock of dab. It is of special interest to examine whether the quantities of fry appearing annually since the introduction of the minimum size-limit are essentially larger than in the years immediately before. The table below brings the average strength figures of the year-classes for 3-years periods between 1925 and 1936:

3-years period	1925/27	1928/30	1931/33	1934/36
The Kattegat	32	37	38	41
The Belt Sea.....	33	54	55	63
Both waters	33	46	46	52

It will be seen that although we find a rise in the quantities of fry after 1934, it is not a very conspicuous one. Of course this rise may be due to the protection obtained by the introduction of the minimum size-limit, but it is just possible that we have to do with the natural annual fluctuations of the quantity

of fry, for a similar increase took place between 1925/27 and 1928/30. But irrespective of size-limit the figures show a considerable increase of the stock of dab in our inner waters during the last decennium. However, a competition for food exists between the dab and the plaice, and so we have reason to ascribe this increase of the dab population to the decrease of the stock of plaice during the same period. In other words: simultaneously with the forcing back of the plaice from its nursery grounds the dab has taken possession of these areas. Attention should be paid to this circumstance now that attempts are being made to re-create a good stock of plaice in the Belt Sea by means of extensive transplantations.

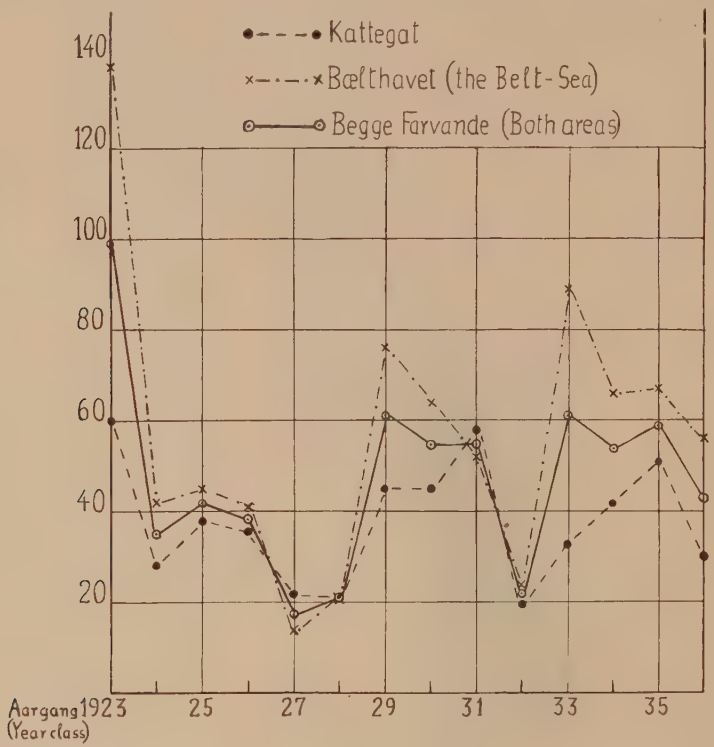

Figure 5. Strength figures (cp. Table on p. 42) of the year-classes 1923—36 in the Kattegat, the Belt Sea, and in both waters together.

On the growth of the dab in various waters.

In Rep. No. XXXVIII of the Danish Biological Station the growth of the dab in the different Danish waters was dealt with in its broad features. The average growth in the different areas appears from the figures below, which state the approximate mean length in cm. of one-year-old (in their passage from the 0-Gr. to the I-Gr.), two-year-old (I—II-Gr.), three-year-old (II—III-Gr.), and four-year-old individuals (III—IV-Gr.):

	1-year-old	2-year-old	3-year-old	4-year-old
The Horns Reef Area	4	10	16	21
The Nissum Broad..	5	11	17	..
The Kattegat	5	13	19	24
The Belt Sea	4	12.5	17	22
The Baltic Proper ..	3	9.5	14	19

The table shows that the growth is most rapid in the Kattegat, somewhat slower in the Nissum Broad, the Horns Reef Area, and the Belt Sea, and considerably slower in the Baltic Proper. The poor rate of growth in the Horns Area is no doubt due to the overpopulation of this area, which contains dense stocks of dab and plaice. The slow growth of the Baltic may be due to overpopulation, but it is just possible that the conditions of the inner Baltic (low salinity) are on the whole unfavourable to the growth of the dab.

In the following will be made a more detailed examination of the growth rate of the dab in different Danish waters for the purpose of establishing to

which degree the growth of the dab is influenced by the density in which the dab and its competitors for food (e. g. the plaice) are in these areas. This investigation rests on analyses of age and length of the dab, carried out by the Danish Biological Station in the years between 1933 and 1936.

1. The North Sea, the Skagerak, and the Nissum Broad.

From these areas we have the following analyses (see the table below) of age and length (in cm.), with numbers of individuals in brackets (the results of the Horns Reef analysis from June 1937 were placed at my disposal by Dr. Aage J. C. Jensen).

The age composition of the analyses shows us that the areas in question, apart from the deeper part of the Horns Reef Area (depths of more than 20 m.), are distinctly to be characterized as nursery grounds, principally sheltering the I- and II-Gr. of dab (and the 0-Gr. although the latter does not occur in the catches, the specimens being too small to be retained by the meshes of the gear applied); of the III-Gr. and older age groups very few or no individuals at all were found. In other words the areas dealt with here are typical nursery grounds where the youngs of both dab and plaice stay for some few years; on the approach of maturity they emigrate to deeper waters farther off from the coasts.

The statements of length given above date from various times during the growth period; in order to make them comparable these figures have been used as a basis of a graphical representation showing the growth in the areas in question (cp. Figure 6). It appears from the graphs that the growth rate is fairly uniform in the Nissum Broad and the Tannis Bay and in both areas somewhat higher than in the Horns Reef Area where the mean length is generally about 3 cm. less than in the two other areas. The slow growth in the Horns Reef Area is due to the fact that the populations of both dab and plaice are much denser here than in the Tannis Bay. But also the Nissum Broad possesses a rather dense stock of these two species of fish; nevertheless, the growth is comparatively rapid here, a fact which must un-

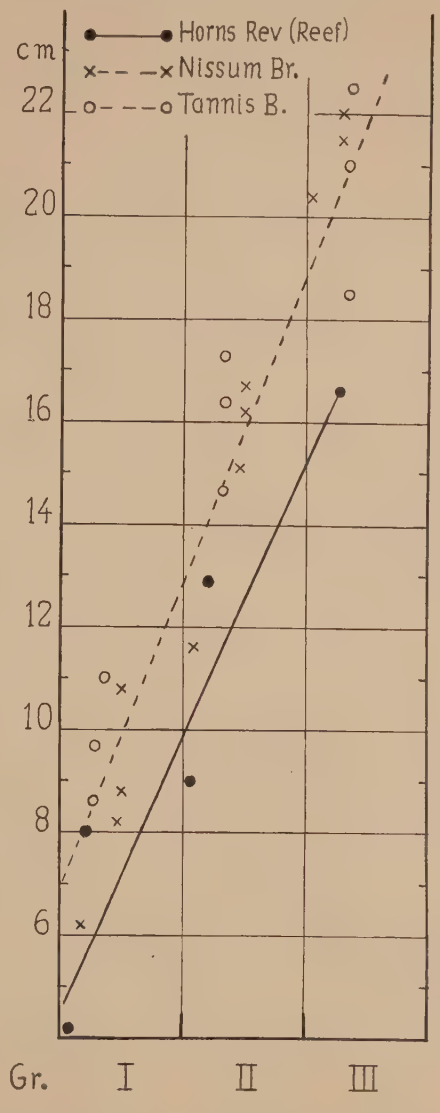

Figure 6. The growth of the dab (I-III-Gr.) in the Horns Reef Area, the Nissum Broad, and the Tannis B. (the Skagerak). For the Nissums Broad and the Tannis B. one graph only is drawn.

Group	I	II	III	IV	V	VI
Horns Reef Area, 20 m., $^{31}/_{3}$ 1933	..	..	22.1 (52)	24.2 (185)	26.1 (68)	26.8 (15)
— — 6—15 m., June 1937	8.0 (1064)	12.9 (390)	16.6 (49)	18.7 (35)	..	..
Nissum Broad, 6 m., $^{21}/_{9}$ 1934	8.2 (48)	16.3 (58)	20.4 (11)	22.7 (6)	..	..
— — — $^{12\text{-}13}/_{5}$ 1935	6.6 (22)	11.6 (137)	20.6 (7)	..	..	..
— — — $^{24\text{-}25}/_{9}$ 1935	8.8 (187)	15.1 (42)	22.5 (4)	..	..	..
— — — $^{18}/_{9}$ 1936	10.7 (291)	16.6 (22)	22.0 (1)	..	..	..
Tannis Bay, 5—17 m., $^{13\text{-}15}/_{7}$ 1934	9.7 (139)	14.7 (27)	18.5 (4)	..	..	..
— — $^{17\text{-}20}/_{8}$ 1935	11.0 (289)	17.4 (141)	23.0 (4)	..	..	..
— — $^{8}/_{7}$ 1936	8.6 (92)	16.4 (22)	21.0 (2)	..	..	..

doubtedly be ascribed to a large immigration during the growth period (in May and June) to this water from the adjoining parts of the North Sea (cp. Erik M. Poulsen, l. c.), i. e. from waters showing an inferior density of population and, consequently, a comparatively rapid growth.

2. The Kattegat.

With a view to examining the growth the Kattegat was sub-divided into the following areas:

1. The Aalbæk B. — Herthas Flak,
2. The Hals Area,
3. Round Anholt, and
4. The Fornæs — Hesselø Area.

The first two areas include the shallow waters along the eastern coast of Jutland. Both are nursery grounds, but in other respects they differ rather much, the area Aalbæk B. — Herthas Flak sheltering a very dense population of dab and especially of plaice whereas the stocks of these two species of fish are much thinner in the Hals Area. The 3rd area — Round Anholt — is mainly a deep-water area with depths ranging between about 20 and 40 m. To some extent this is also the case with the 4th area (Fornæs—Hesselø), but this area also includes some narrow strips along Djursland and the northern coast of Sealand; however, in these coastal areas the stocks of young plaice and dab are but thin, even thinner than in the Hals Area.

Age analyses from these four areas, carried out in the years 1933—36, are given in Table 4. Figure 7 shows the growth of the dab population in the areas. A comparison between the two nursery grounds will show the distinct difference of growth in these areas: in the Hals Area the 2-, 3-, and 4-year-old dab average 3 cm. more than in the Aalbæk B. This difference in

Table 4. Mean length (cm.) of the various age-groups of the dab in the Kattegat, from the investigations in the years 1933—36. No. of spec. in ( ).

Area		Age-group I	II	III	IV	V	VI
Aalbæk Bay—Læsø ...	1933. 22-24/5	..	12.4 (204)	17.5 (36)	18.5 (10)	..	..
	— 21/6	11.4 (61)	15.7 (25)	..	..	..	..
	— 28-29/8	..	13.0 (152)	16.0 (232)	21.1 (11)	..	..
	1934. 20-21/6	9.2 (134)	14.9 (59)	17.3 (23)	24.0 (1)	..	..
	1935. 18-22/7	10.3 (277)	16.4 (229)	20.6 (22)	21.3 (4)	..	..
	— 16/8	11.1 (182)	17.0 (200)	20.5 (79)	19.5 (2)	..	..
	1936. 5-10/7	9.0 (128)	14.8 (135)	21.3 (29)	24.5 (2)	..	..
Hals area.....	1933. 21-28/5	8.8 (4)	16.9 (37)	23.1 (10)	..	..	..
	1934. 1/6	8.7 (31)	16.6 (18)	23.3 (14)	24.0 (1)	..	..
	— 23/6	9.7 (144)	19.0 (40)	23.4 (32)	24.0 (2)	..	..
	1935. 8-17/5	7.7 (31)	16.8 (100)	23.3 (7)	28.0 (1)	..	..
	— 21/8	14.6 (30)	19.7 (31)	24.0 (1)	..	..	..
	1936. 11/7	11.0 (48)	18.3 (28)	19.7 (6)	..	..	..
	— 14/9	17.9 (16)	22.1 (12)	25.0 (3)	..	..	..
Round Anholt.....	1933. 28-29/5	7.7 (9)	13.7 (37)	19.2 (18)	..	..	..
	— 26/8	13.4 (42)	16.3 (239)	20.5 (10)	..	..	..
	1934. 17-19/6	11.5 (46)	15.4 (127)	18.8 (133)	23.2 (31)	29.0 (1)	..
	1935. 11-13/8	9.1 (31)	16.1 (274)	19.5 (67)	29.0 (1)	..	..
	1936. 13-14/7	11.7 (11)	15.3 (84)	18.4 (23)	..	..	..
Fornæs—Hesselø area.....	1933. 20-29/5	9.8 (5)	13.7 (26)	18.4 (15)	21.7 (3)	28.0 (1)	..
	— 10/6	8.9 (26)	13.9 (53)	18.8 (30)	22.3 (9)	27.7 (3)	..
	— 26/9	13.0 (9)	17.2 (37)	21.2 (33)	24.4 (11)	..	..
	1934. 24/5	8.8 (15)	13.0 (33)	15.7 (28)	22.4 (5)	..	..
	— 17/6	8.4 (11)	13.1 (36)	15.8 (81)	19.6 (16)	31.0 (1)	..
	— 19/7	9.0 (21)	14.7 (43)	20.0 (23)	23.5 (2)	..	..
	1935. 7/5	..	13.6 (76)	18.7 (23)	21.6 (12)	..	..
	— 9-10/7	7.4 (193)	15.4 (70)	18.5 (13)	25.0 (2)	..	..
	— 11/8	10.0 (27)	15.3 (131)	17.9 (15)	20.0 (1)	..	..
	1936. 8/9	8.8 (200)	14.8 (127)	19.0 (35)	20.7 (7)	..	..
	— 12-13/9	10.4 (140)	16.0 (123)	21.0 (38)	25.8 (21)	28.7 (3)	34.7 (3)

the rate of growth is also clearly visible if we make a direct comparison between the analyses made in the two areas at fairly the same points of time (numbers of individuals in brackets):

		I-Gr.	II-Gr.	III-Gr.	IV-Gr.
$^{21-28}/_{5}$ 1933	The Aalbæk Bay	..	12.4 (204)	17.5 (36)	18.5 (10)
	The Hals Area	8.8 (4)	16.9 (37)	23.1 (10)	..
$^{20-23}/_{6}$ 1934	The Aalbæk Bay	9.2 (134)	14.9 (59)	17.3 (23)	24.0 (1)
	The Hals Area	9.7 (144)	19.0 (40)	23.4 (32)	24.0 (2)
$^{16-21}/_{8}$ 1935	The Aalbæk Bay	11.1 (182)	17.0 (200)	20.5 (79)	19.5 (2)
	The Hals Area	14.6 (30)	19.7 (31)	24.0 (1)	..
$^{5-11}/_{7}$ 1936	The Aalbæk Bay	9.0 (128)	14.8 (135)	21.3 (29)	24.5 (2)
	The Hals Area	11.0 (48)	18.3 (28)	19.7 (6)	..

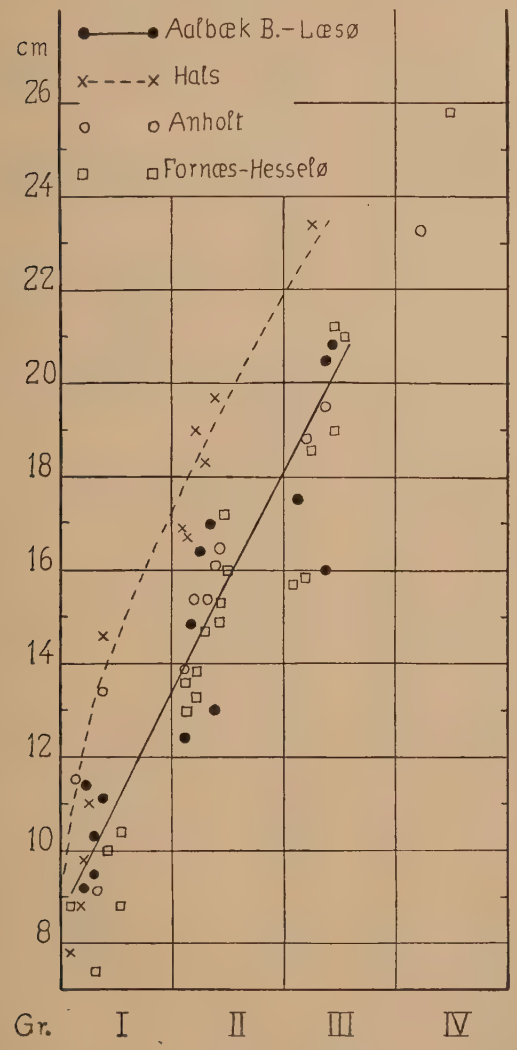

Figure 7. The growth of the dab (I-IV-Gr.) in various areas of the Kattegat (the graphs for the areas Anholt and Fornæs—Hesselø were not drawn because they are nearly coincident with the graphs for the area, Aalbæk B.—Læsø).

We note the outspoken difference between the two areas as regards the growth rate of the dab. No doubt the difference of growth is due to the competition for food. In the Aalbæk B. with its dense populations of dab and plaice the growth is but slow, much slower than in the Hals Area where the stocks are considerably thinner.

In the two deep-water areas the growth is rather poor: round Anholt it is a little more rapid than in the Aalbæk B., in the Hesselø—Fornæs Area approximately the same as in the Aalbæk B. The stocks of both dab and plaice are thin in these two areas, and so the slow growth rate cannot be due to a competition for food among the dab themselves or between dab and plaice. Probably conditions in the deeper water are on the whole unfavourable to the growth of the dab, but it is also possible that the slower growth of these areas is connected with the general decrease in the growth of the dab from the Kattegat through our inner waters and into the Baltic, whether this decrease of growth be a characteristic feature of the dab population of our inner waters or a consequence of a gradual decrease of the growth rate caused by the gradual changes in the hydrographical conditions of the waters from the north towards the south and east.

3. The Belt Sea and the Sound.

Age and length analyses from the various subdivisions of these waters are found in Table 5 and Figure 8. Unlike the Kattegat the Belt Sea does not allow any very sharp distinction between areas showing different densities of population: in the Belt Sea with its highly varying depths even very small areas will show localities with a very dense and others with a very thin population of dab. Broadly speaking it may be said that the dab population is comparatively dense in the areas Aarhus B.—W. of Samsø, N. of Funen, and, to some extent, the Great Belt, whereas it is rather thin in Smaalandshavet and the Sound. The

Table 5. Mean length (cm.) of the various age-groups of the dab in the Belt Sea and the Sound, from the investigations in the years 1935—36, No. of spec. in ( ).

Area		Age-groups I	II	III	IV	V	VI
The Sound	1933. 8/7	10.0 (1)	15.4 (26)	20.2 (43)	23.8 (32)	29.0 (1)	..
	1934. 8-9/7	10.6 (5)	16.5 (39)	20.8 (70)	23.7 (33)	27.7 (3)	..
	1935. 29/4-1/5	9.0 (1)	15.9 (10)	22.2 (24)	23.9 (23)	27.6 (5)	..
	— 7-8/10	10.5 (34)	20.8 (53)	24.4 (30)	27.6 (5)	..	..
The area round Sejrø	1933. 30/5	10.0 (2)	11.8 (32)	18.4 (26)	25.9 (18)	32.9 (8)	..
	— 27/9	11.3 (47)	14.9 (61)	18.9 (33)	22.3 (9)	26.0 (1)	..
	1934. 5-6/7	8.6 (343)	14.3 (67)	18.5 (73)	22.1 (19)	..	..
	1935. 18-23/5	6.3 (104)	12.9 (180)	19.1 (92)	19.4 (65)	27.0 (3)	..
	— 5-11/7	7.7 (325)	13.6 (195)	18.6 (38)	20.6 (56)	21.6 (11)	21.8 (4)
	1936. 4/7	7.9 (202)	12.9 (261)	17.4 (198)	20.4 (52)	22.1 (20)	26.3 (3)
	— 10-12/9	10.1 (277)	15.9 (178)	19.9 (105)	23.5 (29)	25.8 (5)	27.0 (1)
Aarhus bay W. of Samsø	1933. 20/5	8.5 (2)	13.6 (9)	17.9 (15)	22.8 (14)	23.0 (1)	..
	— 16/10	12.1 (35)	15.7 (22)	21.2 (10)	23.8 (6)	25.3 (3)	..
	1934. 4-5/7	9.6 (129)	14.6 (42)	18.2 (136)	21.1 (154)	23.2 (24)	28.0 (1)
	1935. 9/4	..	14.2 (20)	19.7 (27)	22.8 (98)	23.4 (24)	27.0 (2)
	— 19-20/5	7.6 (47)	13.2 (170)	19.2 (77)	21.8 (133)	27.8 (4)	..
	— 5-7/7	8.5 (422)	14.5 (241)	18.0 (90)	21.6 (42)	23.8 (9)	..
	1936. 7/5	7.4 (40)	15.0 (4)	21.5 (19)	23.1 (42)	23.5 (35)	24.0 (3)
	— 8/10	..	13.5 (90)	19.1 (33)	21.4 (8)	..	..
North of Funen	1933. 18-19/5	6.7 (3)	10.1 (102)	15.0 (95)	21.3 (63)	26.2 (14)	..
	1934. 16/5	6.7 (426)	12.1 (22)	14.8 (146)	18.6 (23)	27.0 (1)	..
	— 25/6	7.1 (93)	12.6 (16)	15.2 (44)	21.1 (16)	23.0 (1)	..
	1935. 27/4	..	11.1 (13)	19.7 (13)	20.8 (34)	27.0 (3)	26.0 (1)
	— 21-22/5	6.3 (374)	13.1 (323)	18.1 (141)	21.1 (194)	24.3 (35)	30.0 (1)
Great Belt	1933. 17/5	6.7 (3)	9.8 (138)	15.9 (70)	20.7 (41)	30.0 (1)	..
	— 21/8	8.8 (4)	9.3 (36)	14.3 (4)	21.3 (3)	..	..
	— 6-13/10	10.0 (6)	14.0 (27)	17.0 (53)	23.7 (20)	30.3 (3)	29.0 (1)
	1934. 25/5	..	12.3 (3)	14.6 (20)	20.0 (8)	..	..
	— 21/7	8.9 (363)	16.0 (10)	19.8 (10)	21.3 (4)	23.7 (3)	..
	— 13/8	11.9 (26)	17.1 (28)	21.6 (16)	23.0 (1)	..	..
	1936. 31/8-2/9	8.0 (374)	11.7 (290)	15.8 (132)	19.2 (22)	21.7 (10)	26.0 (1)
	— 6-7/10	12.0 (59)	17.3 (28)	19.9 (1)	21.5 (2)	..	..
Smaalandshavet	1933. 16/5	8.1 (7)	12.5 (20)	17.8 (40)	22.9 (19)	28.0 (1)	..
	— 29/9	11.4 (25)	17.3 (80)	21.6 (45)	25.0 (1)	..	..
	1934. 14-15/8	8.7 (200)	15.0 (12)	19.3 (15)	21.1 (7)	..	..
	1935. 12/4-4/5	8.0 (10)	11.1 (66)	20.9 (19)	24.0 (12)	24.0 (1)	..
Southern Little Belt	1933. 21-26/6	10.2 (38)	13.8 (99)	17.7 (86)	23.1 (12)	31.0 (1)	
	— 9-10/10	9.5 (2)	13.8 (70)	18.7 (14)	25.7 (3)	..	..
	1934. 16-17/5	7.1 (79)	13.9 (41)	17.2 (50)	23.5 (23)	28.7 (9)	..
	1935. 25-26/4	6.0 (1)	12.0 (299)	20.6 (28)	23.3 (16)	26.5 (2)	27.0 (1)
	1936. 29/4	..	17.0 (12)	21.1 (51)	21.6 (5)	19.0 (2)	..
	— 28-29/8	10.6 (197)	15.9 (192)	19.5 (79)	23.0 (11)	..	..

graphs of Figure 8 represent the growth in two areas with a dense dab population (Aarhus B.—W. of Samsø and N. of Funen) and in two areas with a thin population (the Sound and Smaalandshavet). The graphs of the densely populated areas run about 1—3 cm. below those of the areas showing a thin population: also in the Belt Sea the poorest growth is found alongside of the densest stocks of dab. The slowness of growth in the clustered localities appears even more distinctly from a comparison between analyses from the same year and from the same point of time within the growth period as figured in the statements of length given below (numbers of individuals in brackets).

Although some of the analyses include few individuals only, the fact that Smaalandshavet and the Sound in all cases show a higher mean length than the areas Aarhus B.—W. of Samsø and N. of

		I-Gr.	II-Gr.	III-Gr.	IV-Gr.
$^{16-20}/_{5}$ 1933	Smaalandshavet	8.1 (7)	12.5 (70)	17.8 (40)	22.9 (19)
	N. of Funen	6.7 (3)	10.1 (102)	15.0 (95)	21.3 (63)
$^{4-9}/_{7}$ 1934	The Sound	10.6 (5)	16.5 (39)	20.8 (70)	23.7 (33)
	Aarhus B.—W. of Samsø	9.6 (129)	14.6 (42)	18.2 (136)	21.1 (154)
$^{27}/_{4}$-$^{1}/_{5}$ 1935	The Sound	..	15.9 (10)	22.2 (24)	23.9 (23)
	N. of Funen	..	11.1 (13)	19.7 (13)	20.8 (34)
$^{7-8}/_{10}$	The Sound 1935	10.5 (34)	20.8 (53)	24.4 (30)	27.6 (5)
	Aarhus B.—W. of Samsø 1936	..	13.5 (90)	19.1 (33)	21.4 (8)

Funen delivers ample evidences of the growth being slower in the crowded than in the thinly populated regions. So there is no doubt that the growth of the dab population is impeded by the extreme density of the stock in many localities of the Belt Sea. In other words large portions of the Belt Sea are highly overpopulated with dab.

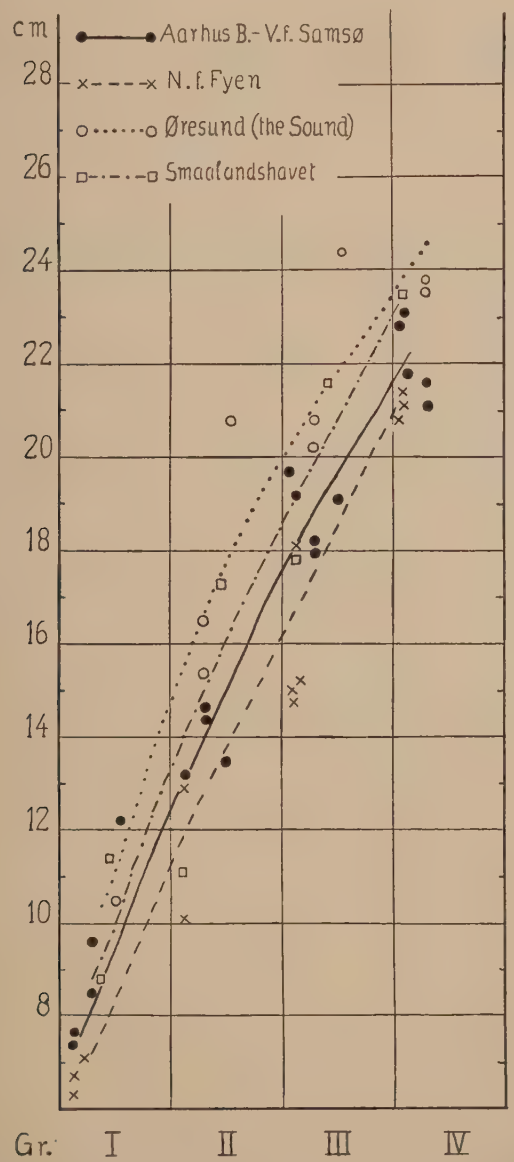

Figure 8. The growth of the dab (I—IV-Gr.) in the Sound and various areas of the Belt Sea.

4. The Baltic.

To this water we here count both the Western Baltic and the Baltic Proper. The Baltic Proper is divided into two areas: the western area including the water west of the line Smygehuk—Arkona, and the eastern one covering the area east of this line or the water round Bornholm and down to the Oder Bank. In Table 6 are the age analyses for these areas from the years 1933—36, and Figure 9 brings the graphical representation of the growth. The most rapid growth takes place in the western part of the Baltic Proper, that is to say the water east of Falster and Møen; the growth is somewhat slower in the Western Baltic and considerably slower in the eastern part of the Baltic Proper where the mean length averages 2—4 cm. less than in the water east of Falster and Møen. The poor growth in the water round Bornholm must apparently be ascribed to the fact that the stock of dab is rather dense here as compared to that of the water west of Smygehuk. Molander, 1925[1]), states that the dab population is thinner in the Arkona Basin than farther eastwards round Bornholm.

As mentioned on p. 35 the dab fishery in the Baltic Proper was very intense in the years 1929—31, and this rise was followed by an extremely deep fall of the yield in 1932—33; so it must be concluded that a marked thinning of the dab population has taken place in the said years. On account of the thinning the stock must now be supposed to live under better conditions of nutrition than formerly; so it will be

[1]) A. Molander: Undersökninger över Rödspotta (*Pleuronectes platessa L.*), Flundra (*Pleuronectes flesus L.*) och Sandskädda (*Pleuronectes limanda L.*) i södra Östersjön. Svensk. Hydr.-Biol. Kom. Skr. N. S. Biologi I, 1, 1925.

of interest to examine whether an increase of the growth rate of the dab has taken place during recent

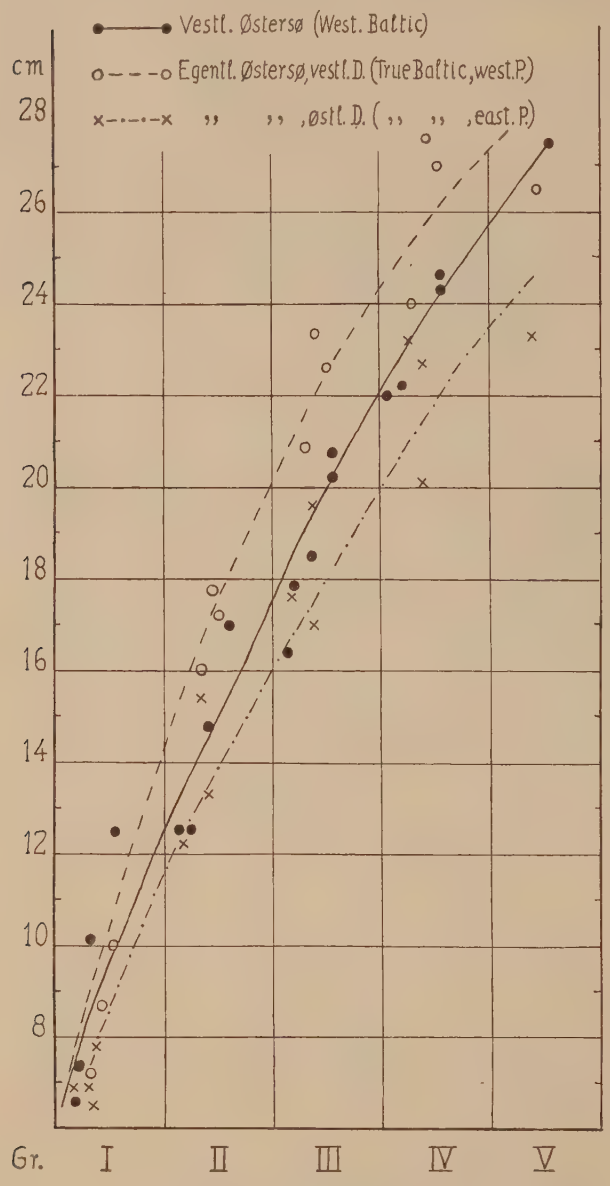

Figure 9. The growth of the dab (I-IV-Gr.) in the Western Baltic and the Baltic Proper.

years as was the case with the plaice after the great thinning of the stock of this fish in the years about 1924—25. For this purpose we shall compare the results from the years 1933—36 with some mean lengths from 1919 and 1925 given by A. Molander (1925)[2]).

[1]) A. Molander: Recent Swedish researches into the fish population of the southern Baltic. Svensk. Hydr.-Biol. Kom. Skr. N. S. Biologi I, 2, 1925.

Molander's material exclusively comprehends dab of the III-Gr. and older age groups. The survey below gives the analyses of the different years (numbers of individuals in brackets):

	III-Gr.	IV-Gr.
Off Ystad, July 1919	11.5 (2)	14.4 (31)
The Arkona Basin, Oct. 1925	17.2 (4)	18.6 (32)
The Baltic Proper, E. part, Aug. 1933	17.0 (63)	20.1 (144)
- — — — — 1934	19,6 (13)	22.8 (6)
- — — W. part, — 1934	23.4 (20)	27.6 (7)
- — — — Sept. 1936	22.6 (6)	27.0 (1)

	V-Gr.	VI-Gr.
Off Ystad, July 1919	15.5 (24)	16.4 (5)
The Arkona Basin, Oct. 1925	19.4 (31)	20.7 (14)
The Baltic Proper, E. part, Aug. 1933	23.3 (22)	30.5 (2)
- — — — — 1934	27.0 (1)	27.7 (3)
- — — W. part, — 1934	..	..
- — — — — 1936	26.0 (1)	..

The survey distinctly corroborates the fact already demonstrated by A. Molander, viz. that a rapid increase of growth took place during the years between 1919 and 1925, no doubt in connexion with the fargoing thinning of the plaice population occurring towards the year 1925. But it further appears from the figures that a most rapid increase of the growth rate took place also during the period between 1925 and 1933—36, i. e. the years during and after the extensive dab fishing in the Baltic; these changes in the conditions of growth are clearly seen from Figure 10 with its graphical representation of the results of the analyses mentioned above. From 1919 to 1925 the increase of the mean length of the age groups III—VI

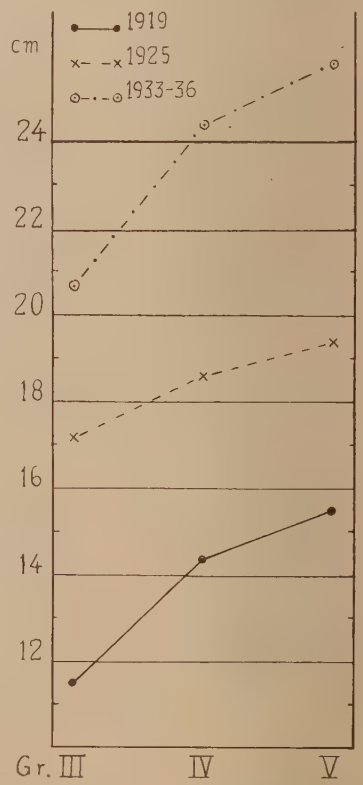

Figure 10. Mean lengths of dab of the III-, IV-, and V-Gr. in the Baltic in the years 1919, 1925, and 1933—36.

Table 6. Mean length (cm.) of the various age-groups of the dab in the Western and the True Baltic, from the investigations in the years 1933—36. No. of spec. in ( ).

Area		Age-groups I	II	III	IV	V	VI	VII +
Western Baltic	1933. $^{26}/_{6}$-$^{4}/_{7}$	7.4 (28)	12.5 (13)	17.8 (22)	21.7 (7)	..	..	..
	— $^{8}/_{10}$	..	..	20.8 (17)	24.3 (31)	..	..	..
	1934. $^{18}/_{5}$	6.6 (11)	12.5 (29)	16.4 (16)	21.0 (2)	25.6 (5)	..	..
	1936. $^{28}/_{8}$	10.1 (7)	14.8 (79)	18.5 (30)	21.5 (2)	..	..	..
	— $^{23}/_{10}$	12.5 (14)	17.0 (60)	20.2 (21)	24.7 (3)	27.5 (2)	19.8 (4)	..
True Baltic, western part[1]	1933. $^{5-6}/_{7}$	7.2 (194)	16.0 (28)	20.9 (42)	24.0 (1)	..	..	..
	1934. $^{16-17}/_{8}$	8.8 (379)	17.8 (74)	23.4 (20)	27.6 (7)	..	..	..
	1936. $^{3}/_{9}$	10.0 (38)	17.2 (27)	22.2 (6)	27.0 (1)	26.0 (1)	..	..
True Baltic, eastern part[2]	1933. $^{6-13}/_{8}$	6.5 (166)	12.3 (4)	17.0 (63)	20.1 (44)	23.3 (22)	30.5 (2)	30.0 (1)
	1934. $^{20-26}/_{8}$	7.8 (123)	13.3 (10)	19.6 (13)	22.8 (6)	27.0 (1)	27.7 (3)	..
	1935. $^{13-27}/_{6}$	6.8 (16)	12.4 (52)	17.8 (72)	23.3 (13)	26.5 (4)	28.0 (1)	33.0 (1)
	1936. $^{20-26}/_{7}$	6.8 (48)	15.5 (38)	19.0 (6)	23.5 (2)	27.3 (3)	..	..

[1]) West of Arkona-Smygehuk.
[2]) East of Arkona-Smygehuk.

amounts to about 4 cm.; in the period between 1925 and 1933—36 the corresponding increase is about 3—6 cm. Accordingly, the dab population of the Baltic shows much the same increase of the growth rate as its stock of plaice, a development which is due to the thinning caused by the intense fishing.

On the relations between individual quantity and growth rate of the separate year-classes.

As mentioned on p. 43 variations between rich and poor spawning years may be pointed out in the Kattegat and the Belt Sea, the two waters in which extensive investigations were carried out. It has been demonstrated above that the growth rate of the dab is highly dependent on the density of the stock, and so it is reasonable to examine whether the growth rate of the individual year-classes depends on their numerical strength, or in other words whether the rich year-classes show a slower growth than the poor ones. Such an examination will be carried out in the following on the basis of analyses of age and length from the years between 1933 and 1936; in these analyses the year-classes 1930—35 are represented by fairly large quantities of individuals per age group.

Among these year-classes in the Kattegat (see p. 43) the 1932 year-class is a poor one (with a calculated strength figure of 22 only), whereas the 1931 and 1935 year-classes are comparatively rich ones (with strength figures of 58 and 52, respectively). In Figure 11 the growth of the 1922 year-class and the year-classes 1931 and 1935 have been given a graphical form on the basis of Table 4 (the figure contains only such statements of length as are based on quantities of 35 individuals or more). The Hals Area, which exhibits a considerably higher growth rate than the other areas of the Kattegat, was not included. As will be seen from the figure the length of the individuals of the poor 1932 year-class is on the whole somewhat greater than that of the rich year-classes 1931 and 1935, the graph of growth running about 2 or 3 cm. higher in the former than in the latter case. There is, consequently, a distinct difference of growth rate between rich and poor year-classes.

In the Belt Sea the year-classes examined show that here, too, the 1932 year-class is poor, while the year-classes 1930 and 1933 are particularly rich ones. As the growth is rather different in the various parts of the Belt Sea, only the densely populated areas with a fairly uniform (and slow) growth were considered, viz. the areas Aarhus B.—W. of Samsø, N. of Funen, and the Great Belt; as in the Kattegat only mean lengths based on quantities of 35 individuals or more were considered. The result of the comparison between the poor 1932 year-class and the rich year-classes 1930 and 1933 appears from Figure 12. Here the graph of growth runs about 2—2.5 cm. higher for the 1932 year-class than for the year-classes 1930 and 1933. Like the Kattegat the Belt Sea shows

the growth of the poor year-classes to be rather more rapid than that of the rich ones.

Figure 11. Mean lengths of the 1932 year-class and of the year-classes 1931 + 1935 in some areas of the Kattegat (the Aalbæk B.—Læsø, Round Anholt, and Fornæs—Hesselø).

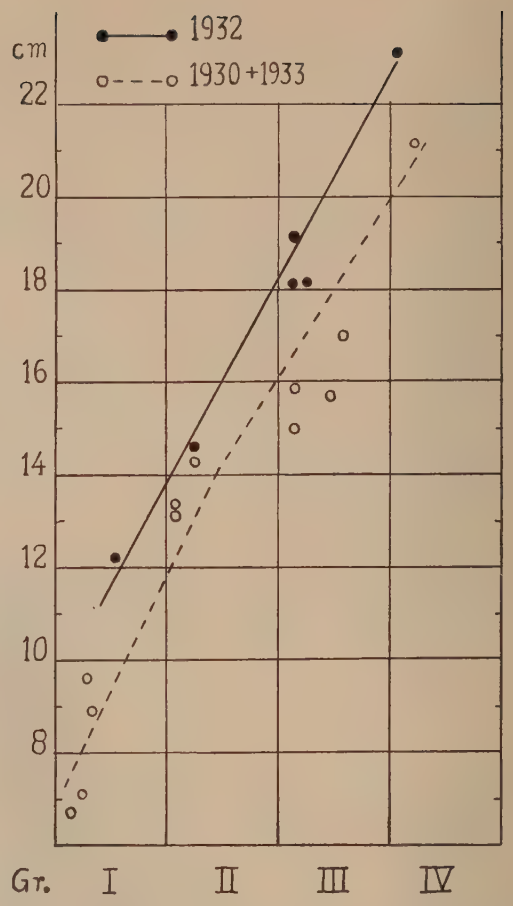

Figure 12. Mean lengths of the 1932 year-class and of the year-classes 1930 + 1933 in some areas of the northern Belt Sea (the Aarhus B.—W. of Samsø, N. of Funen, and the Great Belt).

Conclusion.

The present researches into the density and growth conditions of the dab population of the Danish waters have led to the following main results.

1. During the years after 1922 a marked rise in the yield of the dab fishery has on the whole taken place in the Danish waters. In the North Sea this rise is being continued. In the Kattegat the yield reached its maximum in 1926 and 1927 and has since that time maintained nearly the same level although with annual fluctuations of some extent. In the Belt Sea the maximum was not reached until 1931, and the yield has been practically unaltered during the following years. In the Baltic Proper the yield of the dab fishery rises most rapidly between 1929 and 1931 in order to fall by approximately the same amount from 1932 to 1934. On the whole it may be said — and this is particularly true of the Baltic Proper — that the yield of the dab fishery rises when that of the plaice fishery is falling, or in other words: the fishery takes an interest in the less valuable dab when the catches of the more valuable plaice fail. Within the same period in which the yield of the dab fishery has risen so rapidly there has at the same time been a marked rise in the market value of this fish, and so the increased supplies have not brought down prices. The minimum size-limit for dab introduced in 1934 has only been of slight importance as a price-raising factor (see p. 39).

2. An examination of the variation in the density of the dab population during recent

years has shown that the stock of the North Sea and the Skagerak has grown denser alongside of the decrease in the density of the plaice population within the period 1903—30 (see p. 39). In the Kattegat and the Belt Sea, where an intense dab fishery has been carried on after 1922, the fishing experiments made in 1922—30 established a decrease of the stock as compared to the period between 1903 and 1911; the intensity of the fishery has apparently caused a thinning of the stock. As mentioned on p. 41 the thinning of the dab population of the Kattegat and the Belt Sea was not continued after 1930; in the Belt Sea the stock has even grown denser during recent years. So there is nothing to indicate that the dab population of our waters is being threatened by the intense fishery. This is accounted for by the fact that the dab unlike the plaice, which is highly threatened by the fishery, begins to spawn at a size considerably below that of the marketable fish. In our inner waters the plaice does not become mature until it has nearly reached the minimum size-limit, whereas the maturity of the dab begins at a far smaller size: in the Belt Sea most of the females are mature already at a length of about 14 cm. and most of the males even at a length of 9 cm. only. Therefore a minimum size-limit is unnecessary for the purpose of ensuring the breeding of the dab.

3. As regards the individual quantities of the separate year-classes the dab, like other species of fish, show considerable annual variations. In the Kattegat and the Belt Sea the year-classes 1927—28 and 1932 were poor, while those dating from 1923, 1929, 1930, 1931, and 1933—36 were rich ones. Broadly speaking the period 1924—28 is conspicuous by its poor, the period 1929—36 by its rich spawning years; the many good spawning years of the latter period have caused the rich occurrence of young dab in our waters, particularly during recent years in certain parts of the northern Belt Sea. Up to now the minimum size-limit introduced in 1934 has not brought about any conspicuous rise in the occurrence of fry, partly because it has been in force for so few years, partly because — as mentioned — a great part of the spawning stock of dab consists of small individuals, which, on account of their inferior value, were of slight importance to the fishery also before the introduction of the minimum size-limit.

4. The growth rate of the dab varies rather much from one water to the other. Certain areas — the nursery grounds — are crowded with dab, and to some extent with plaice; here the growth is comparatively slow. Such areas are above all the Horns Reef Area, the Aalbæk B., and certain parts of the northern Belt Sea (see p. 44). In other areas, especially in somewhat deeper water, the population is thinner and the growth therefore more rapid. Generally speaking we may say that the growth of the dab decreases from the Kattegat through the Belt Sea and into the Baltic.

5. As regards the relations between the individual quantity and the growth rate of the separate year-classes it has been demonstrated that the poor year-classes are growing more rapidly than the rich ones. This state of things shows us that the competition for food among the dab is so intense, that it may impede the growth of the individual specimens; this also appears from the above mentioned difference of growth rate between thinly and densely populated areas.

The dab population of our inner waters between the Skaw and Gedser has experienced a considerable augmentation during recent years. There are several causes of this fact; firstly, we have had a large number of good spawning years after 1929; secondly, the constant thinning of the stock of plaice — the competitor of the dab as regards food — has brought about better conditions for the dab; thirdly, the minimum size-limit introduced in 1934 has caused a certain, although up to now rather inconsiderable rise in the appearance of fry. However, the occurrence of large quantities of fry also in the years before the introduction of the minimum size-limit shows us that the latter is by no means a biological condition of the preservation of the dab population in Danish waters. A sufficient supply of dab fry is fully ensured by the fact the dab begins to spawn long before reaching the marketable size.

As demonstrated in a previous paper (Rep. Dan. Biol. Stat. XXXVIII) the dab and the plaice are eager competitors for food. In our inner waters, where — e. g. by means of close seasons and transplantations — various expensive attempts are being made to preserve or rather to rear up a productive stock of plaice, the occurrence of a dense dab population is not to be wished for; on the contrary, the competition of the latter may involve a certain danger to the stock of plaice, so that it may in some way come to counteract the efforts that are being made to improve

the stock of plaice. The dab is, and will no doubt continue to be a less valuable fish than the plaice, and so it should not be allowed to expel the latter from the nursery grounds. Whether this takes place already at present is of course difficult to decide, but during the fishing experiments of the Danish Biological Station in the Belt Sea in the course of recent years it has been observed in many localities that the stock of young dab is considerably denser than some years ago; in the same localities the stock of young plaice is but thin although it seems clear that the area in question must be able to shelter and feed a population of growing plaice. Attention should be paid to this fact in future. It is not to the benefit of the Danish fisheries if the dab are gaining in numbers at the sacrifice of the plaice. Two facts of widely different nature place the dab in a much more favourable position than the plaice in the struggle for life; firstly, the dab spawns at a much smaller size than the plaice, and so the individual specimens of dab are much more likely to spawn before being caught than are the individual specimens of plaice; secondly, the dab is a less valuable fish and is consequently not so eagerly fished for as the plaice. If both species of fish are to live and thrive in the same water, the plaice must be protected in a much higher degree than the dab.

The Races of Dab in the Danish Waters.

By

AAGE J. C. JENSEN

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I. The importance of the racial investigations.

In all cases when researches have been made into the races of fish, it has turned out that each race makes its definite requirements on the physical conditions of the sea and, under the same conditions, shows a specific rate of growth.

On the basis of the extensive marking experiments that have been undertaken alongside of the large transplantations of plaice from the North Sea to the Belt Sea Dr. Blegvad was for instance able to prove that plaice of the North Sea race are apt to favour a little greater depths of water than the local Belt Sea plaice, and it also became apparent that the growth rate of the transplanted North Sea plaice is much higher than that of the local fish[1]).

In his investigations on the races of plaice Dr. Johansen showed that the racial character (and the growth rate) of the plaice of our inner waters have been subject to radical changes during the last few decennia, approaching the character of the North Sea race, at the same time as the fishery has been thinning the stock[2]).

It has been possible to demonstrate that the fishery in these waters changed the proportion between the quantities of spawning local Belt Sea fish and immigrated spawning fish of the North Sea race in a way as to cause an increased crossing of the two races[3]).

As far as the dab is concerned a corresponding change of the racial character seems to have taken place in some inner Danish waters (as pointed out in Section III of this paper). The researches are being continued, but already at the present stage of investigation several biological facts of practical scientific interest have been found to be connected with the racial character, so that it seems reasonable to make a comparison between the results achieved until now.

II. The racial character.

As is the case with for instance plaice, cod, and herring several races of dab are found in the waters surrounding Denmark. A short preliminary survey basing on the greater part of the material then in hand was given by E. M. Poulsen in 1933[4]).

Generally the number of vertebrae is a good mark by which to distinguish different races, but the dab proves to be an exception from this rule. In 1932 R. Kändler showed that the dab of the Baltic Proper had an especially large number of fused vertebrae, and in 1933 Poulsen summed up the preliminary result of the racial investigation on the dab population of our waters in the following way: "The Baltic dab, as compared to the North Sea dab, is characterized by (1) a smaller number of anal fin rays, (2) a more frequent occurrence of anomalies in the vertebral column, and (3) very likely a smaller number of vertebrae" (l. cit., p. 17). However, a statistical examination shows that Poulsen's material of 89 dab from the Baltic Proper does not allow us to draw any conclusions as to the presence of differences although such a conclusion would seem an obvious one because the plaice, as is well known,

[1]) H. Blegvad: Transplantations of Plaice from the North Sea to the Belt Sea 1928—1933. Rep. Dan. Biol. Stat. XXXIX. 1934.

[2]) A. C. Johansen: On some characters of the Baltic Plaice which have changed during the last decennaries. Rapp. et Proc. Verb. Vol. LIV, 1929.

[3]) Aage J. C. Jensen: Periodic Fluctuations in the size of various stocks of fish and their causes. Medd. f. Komm. for Danmarks- Fiskeri og Havundersøgelser. Ser. Fiskeri. Bd. IX, Nr. 5, 1932.

[4]) E. M. Poulsen: Biology of the Dab in Danish Waters. Rep. Dan. Biol Stat. XXXVIII, 1933.

has fewer vertebrae in the Baltic than in the North Sea.

From the North Sea the following samples were in hand: in 1905 A. C. Johansen had found

in the Horns Reef Area .... Vert. S.*) = 40.24 (50 ind.)
in the Skagerak ..... Vert. S. = 40.51 (37 ind.)

*) The total number of vertebrae.

and Poulsen found in 1933 in the Horns Reef Area (near the Graadyb L. V.) Vert. S. = 40.30 (84 ind.).

If we add up all these dab from the North Sea (differences between the groups of this material cannot be established), we get Vert. S. = 40.33 ± 0.05.

A comparison with Poulsen's counts from the Bornholm Area, which show the mean number 40.19 ± 0.06, gives a difference of 0.14 between the mean numbers of vertebrae in the two areas while the standard error of the difference, $\sigma_{Diff.}$, is 0.08. So we do not perceive any difference between the samples of the two areas. This is also the case if we compare only the two samples examined in 1933.

Furthermore, A. C. Johansen had in 1903 examined 30 dab from the Bornholm Area and found the mean 40.30. In order to make sure whether the fact that no difference could be made out between the numbers of vertebrae at Bornholm and in the North Sea must be put down to the smallness of the material, I examined the number of vertebrae in 193 dab caught 4 naut. miles N. of Gudhjem (depth about 60 m.) on 7. Feb., 1938. In 17 individuals (9 per cent.) I found properly fused vertebrae with a suture between and in 31 individuals (16 per cent.) complex vertebrae in the front or hind part of the spine without any traces of fusion (without a suture), but with 2 or more upper and (or) lower spinal processes. It may be noted that the two processes on the same side of the vertebra may be totally detached from each other, nearly free, or more or less fused in their whole length. Here the vertebra was considered complex if two processes could easily be distinguished although they were fused in their whole length.

In these dab from N. E. of Bornholm the number of vertebrae was as follows:

176 dab without fused vertebrae ..... Vert. S. = 40.26 ± 0.06
all 193 dab examined ..... Vert. S. = 40.29

It is seen at once that an actual difference in the total number of vertebrae between the North Sea dab and the Baltic dab cannot be demonstrated.

The number of pre-caudal vertebrae in the sample from N. E. of Bornholm was 10.10 ± 0.03 (187 without fused vertebrae). Neither here nor in the number of caudal vertebrae can any difference be traced between North Sea dab and Baltic dab.

Countings of vertebrae in samples of 38 and 20 dab from the coastal water E. of Falster and S. of Møen were made by A. C. Johansen on 14-I-04 and 16-XI-05, respectively. The former examination was quoted by Poulsen in the paper mentioned above.

In the two samples together the numbers of vertebrae were as follows:

Vert. pre-caud.		Vert. S. (total number)	
No. of vert.	No. of ind.	No. of vert.	No. of ind.
10	54	39	7
11	4	40	35
		41	15
Total...	58	42	1
Mean...	10.07	Total...	58
		Mean...	40.17 ± 0.08

The difference in the total number of vertebrae between this sample and the one from N. E. of Bornholm (7-II-38) is only 0.09. $\sigma_{Diff.}$ also being 0.09 there is no very great probability that an actual difference in the number of vertebrae is found between dab from these two areas of the Eastern Baltic.

The number of anal fin rays. In contrast to the number of vertebrae the number of anal fin rays shows a considerable variation from place to place. The average numbers of anal fin rays in the areas examined are as follows:

[1]) The formulae used: $\sigma = \sqrt{\frac{n\Sigma pa^2 - (\Sigma pa)^2}{n(n-1)}}$, $\sigma_m = \frac{\sigma}{\sqrt{n}}$, $\sigma_\sigma = \frac{\sigma}{\sqrt{2n}}$, $\sigma_{Diff.} = \sqrt{\sigma_{m_1}^2 + \sigma_{m_2}^2}$, where a is the variate from a proximate mean, p the number of this variate, n the total number of variates.

Table 1. Numbers of anal fin rays in dab from different areas of the Danish waters, 1930—38.

Area	Anal fin rays Mean	No. of dab	Years of investig.	Counted by
Southern Horns Reef Area	56.6	102	1933	Poulsen
		242	1933—34—36—37	Jensen
Northern Horns Reef Area	56.5	109	1933—36	—
Off Thyborøn	57.8	147	1937	S. W. Fogh
The Skagerak	57.4	52	1930	Jensen
Northern Kattegat	56.1	50	1933	Poulsen
Central Kattegat	54.9	31	1930—31	Jensen
Southern Kattegat	55.1	192	1934—36—37	—
Northern Belt Sea	54.4	436	1930—33—36—37	—
		71	1933	Poulsen
Great Belt	54.5	172	1933	—
		168	1933—35—37	Jensen
Smaalandshavet	54.6	140	1930—31—35—36—37	—
Western Baltic + S. of Funen	54.4	372	1930—33—36—37	—
The Sound + S. of Møen	54.8	87	1930—35—36—37	—
Bornholm	53.2	107	1933	Poulsen
		188	1938	Jensen

It is noted that the highest mean figure for the total number of anal fin rays is found in the northern part of the water off the western coast of Jutland and in the Skagerak while it is inferior by nearly one ray at the Horns Reef. Through the Kattegat there is a rapid decrease to the northern part of the Belt Sea, from about 56 to about 54.5. Throughout the Belt Sea and the adjacent part of the Baltic (the coastal shallows of Zealand, Møen, and Falster) the number of anal fin rays is constant, about 54.5, but at Bornholm it is again lower by more than one ray, about 53.

Apparently, the mean number of anal fin rays in the area S. of Møen is a little higher than in the Belt Sea, which seems to indicate that a minor part of the population in the westernmost parts of the Baltic Proper is recruited from the southern Kattegat through the Sound.

III. Variation of the racial character from year to year.

The mean number of anal fin rays, however, is found to vary not only from one place to the other, but also from year to year within the same locality.

The number of anal fin rays in the different year-classes are given in Table 2, which includes counts basing on quantities of at least 20 specimens. These variations from year to year are so distinct, too, that they must be considered a reality.

We see for instance that the mean numbers for the 1929 and 1930 year-classes from the Horns Reef are nearly uniform, being 56.05 and 55.81, respectively. If we contemplate these two year-classes together, we get a sample of totally 91 individuals with the mean number 55.96 ± 0.22. The difference from the value found for the 1935 year-class, 57.08, being 1.12, and the standard error of the difference $\sigma_{Diff.}$ being 0.36, the difference is in this case more than 3 times $\sigma_{Diff.}$, and so it seems justifiable to say that an actual difference exists between the stocks of the two years. Also the difference found between the 1927—28 (74 ind.) and the 1928—29 year-classes is most probably a reality.

Several of the mean figures, however, have been determined on the basis of so small a material, that we cannot decide whether they are in fact different from those found in the other years because the difference is too slight as compared to the size of the sample. This is for instance the case with the 1934 and 1935 year-classes in the Horns Reef Area. The mean values of these years differ by 0.69, and the standard error of the difference is 0.38. The difference not being twice $\sigma_{Diff.}$, it is not great enough to justify the conclusion that a difference exists between the stocks of the two year-classes.

In the northern Belt Sea we have particularly large samples from 1934 and 1935 with a difference between the mean figures of 0.79, which is more than three times the standard error of the difference.

Table 2. Number of anal fin rays of the various year-classes of dab in the Danish waters.

Area	Horns Reef Area							Off Thyborøn			Southern Kattegat		The Sound S. of Møen	
Year-classes	1927	1928	1929	1930	1933	1934	1935	1932	1933	1934	1934	1935	1933	1934
No. of rays														
50	..	..	..	..	..	..	..	..	..	..	..	..	1	..
51	..	..	..	1	..	..	2	..	..	..	2	2	2	..
52	1	..	1	2	1	1	..	..	..	..	7	3	1	4
53		1	6	..	2	4	1	..	5	1	8	9	5	2
54	1	7	6	6	11	5	7	3	5	2	8	12	6	6
55	2	5	10	6	8	11	4	2	5	1	9	11	5	7
56	3	8	9	9	11	13	11	5	12	6	18	14	5	5
57	7	7	10	7	13	12	13	5	15	1	9	12	1	1
58	5	7	5	1	12	11	12	3	16	2	4	4	2	1
59	4	6	5	3	8	7	6	6	12	3	1	..	..	..
60	4	3	3	..	2	2	5	4	14	1	1	..	1	..
61	..	3	..	..	1	..	4	1	6	1	..	1	..	..
62	..	..	..	1	..	..	..	..	4	1	..	1	..	..
63	..	..	..	..	..	..	1	..	3	..	..	..	..	..
64	..	..	..	..	..	..	..	..	1	1	..	..	..	..
No. of dab	27	47	55	36	69	66	66	29	98	20	67	69	29	26
Mean	57.37	57.06	56.05	55.81	56.49	56.39	57.08	57.45	57.96	57.45	55.06	55.23	54.52	54.54
σ	1.94	2.15	2.05	2.19	1.95	1.99	2.34	2.01	2.51	2.84	2.01	2.05	2.21	1.58
σ_m	0.37	0.31	0.28	0.36	0.24	0.24	0.29	0.37	0.25	0.63	0.25	0.25	0.41	0.31

Area	Northern Belt Sea					Great Belt — Smaalandshavet					Western Baltic			At Bornholm		
Year-classes	1931	1932	1933	1934	1935	1929	1930	1933	1934	1935	1933	1934	1935	1932	1933	1934
No. of rays																
47	..	..	..	..	..	..	..	..	..	..	..	..	..	1	..	..
48	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
49	..	..	..	..	..	..	..	.	..	..	..	..	..	1	..	..
50	1	1	..	2	..	..	..	..	2	..	1	1	..	5	5	2
51	3		1	2	4	1	..	..	1	2	5	4	2	7	9	1
52	3	3	5	15	11	3	3	7	3	11	11	18	4	5	16	14
53	12	7	12	31	12	7	7	7	6	8	15	27	5	8	10	12
54	12	5	6	38	25	8	8	7	13	17	24	41	7	4	9	11
55	8	4	16	31	24	12	13	7	10	14	20	45	4	5	4	9
56	4	7	7	11	21	1	4	2	15	12	14	31	8	2	3	2
57	2	1	3	10	13	..	3	3	2	6	6	20	2	4	1	7
58	1	..	2	3	8	1	..	1	1	2	..	1	..	..	1	..
59	..	..	..	..	2	..	..	..	1	2	..	3	2	..	..	..
60	..	..	..	..	2	..	..	..	..	..	..	..	..	..	..	..
61	..	..	..	..	1	..	..	..	..	..	..	..	1	..	..	..
62	..	..	..	1	..	..	..	..	..	..	..	..	..	..	..	..
No. of dab	46	28	52	144	123	33	38	34	54	74	96	191	35	42	58	58
Mean	53.89	54.14	54.42	54.19	54.98	54.06	54.45	54.09	54.59	54.51	54.10	54.56	54.69	52.81	52.76	53.71
σ	1.66	1.67	1.63	1.70	2.02	1.37	1.35	1.68	1.78	1.84	1.62	1.67	2.27	2.56	1.81	2.12
σ_m	0.25	0.32	0.23	0.14	0.18	0.24	0.22	0.29	0.24	0.21	0.17	0.12	0.38	0.39	0.24	0.28

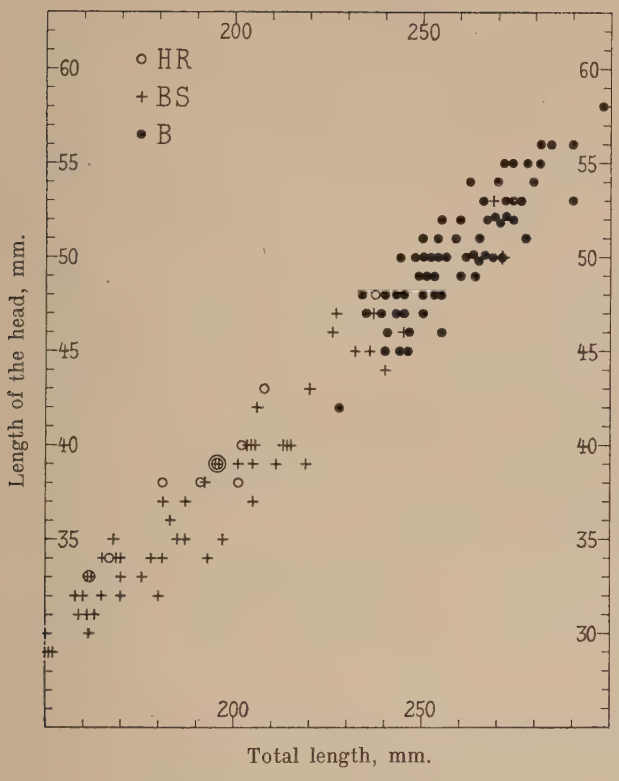

Fig. 1. Comparison between total length of the dab and the length of the head in different areas.
HR: Horns Reef area.
BS: Belt Sea and Western Baltic.
B: Round Bornholm.

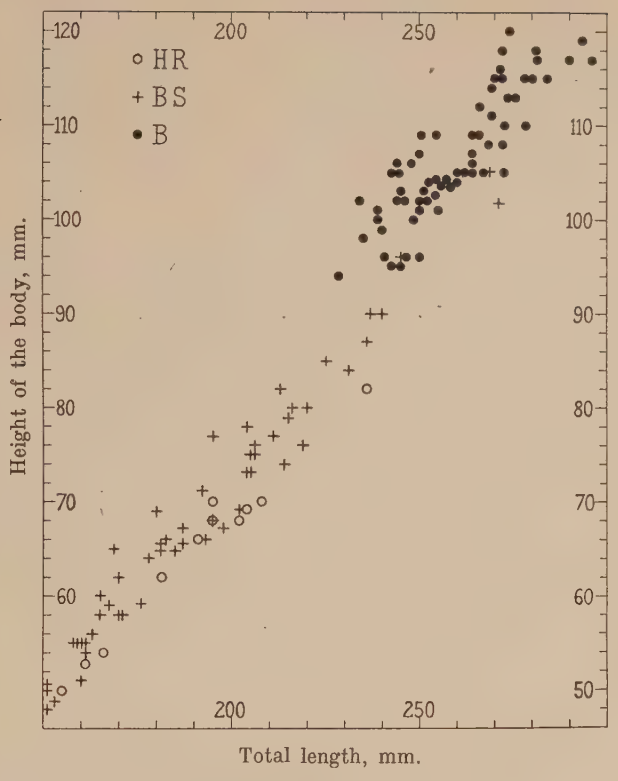

Fig. 2. Comparison between total length of the dab and the height of the body.
Signature as in Fig. 1.

In the Bornholm Area the mean number of anal fin rays of the year-classes 1933 and 1934 differ by 0.95. The standard error being for this difference 0.38, the difference is between 2 and 3 times $\sigma_{\text{Diff.}}$, and so there is some probability that the said difference actually exists and is not merely a consequence of the material being too small.

It should be remembered that if we consider 2 samples chosen from among a number, c, of dab samples taken at random from the actual stock, the possibility of choosing such a pair where a certain difference being exceeded is $(c-1)+(c-2)+..+2+1$ times greater than will be the case if we only consider 2 samples taken at random. If among 4 mean numbers of the year-classes of some area we choose 2 for a comparison, the chance of a certain difference being due to a casual variation is 6 times greater than if the two year-classes had been the only ones known. On the other hand the probability of a difference stated being a reality increases with the number of cases in which a difference can be ascertained in the samples pairde.

The cases in which the difference between two year-classes is so great, that it is most rarely caused by a casual variation, are here so numerous, that we may safely assume that the racial character of the dab actually varies from year to year inside the separate areas.

Changes of the racial character of the dab in the course of time.

From the northern or central Kattegat (no exact locality given) we have an examination of 106 dab carried out by Dr. Th. Mortensen[1]) in 1895. 100 dab from the northern Kattegat were examined by A. C. Johansen in March, 1906. These two samples gave the following mean numbers:

[1]) Th. Mortensen: Fortsatte Undersøgelser over Rødspætteyngelens Forekomst i Østersøen i 1894 og 95. Beretn. Dansk Biol. Stat. V. 1896.

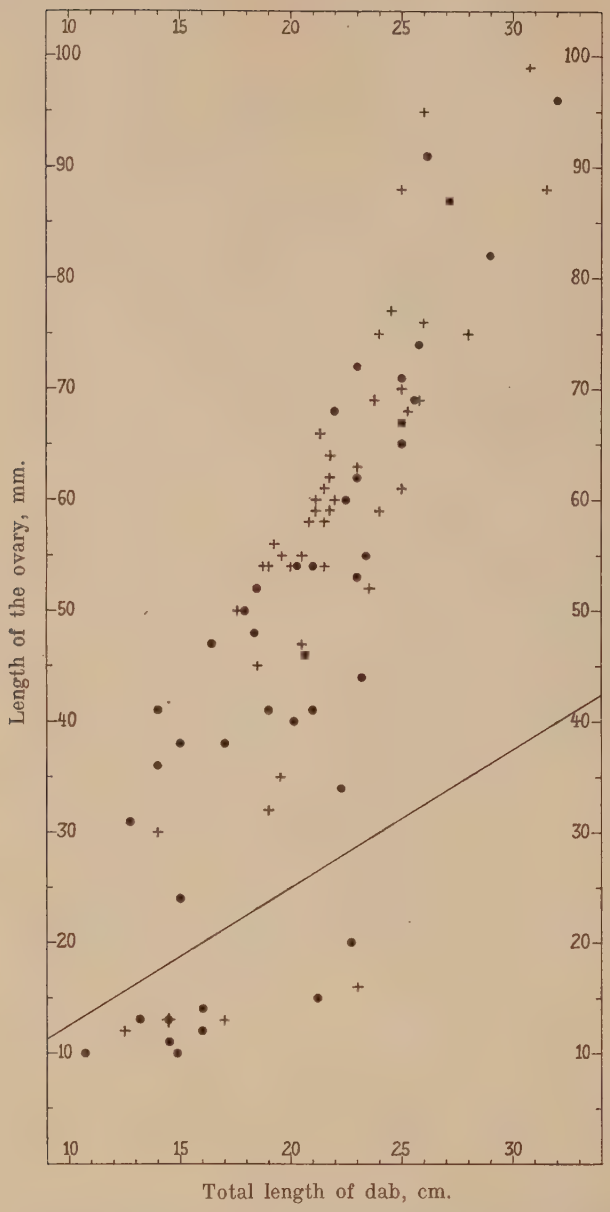

Fig. 3. Length of the ovary at different length of the dab in the Northern Belt Sea during April—May 1935, 36 and 37.
At depths less than 16 m.: +
Deeper than 20 m.: ●
The sloping line indicate the limit for size of the ovary in immature young-fishes (maturity I—II).

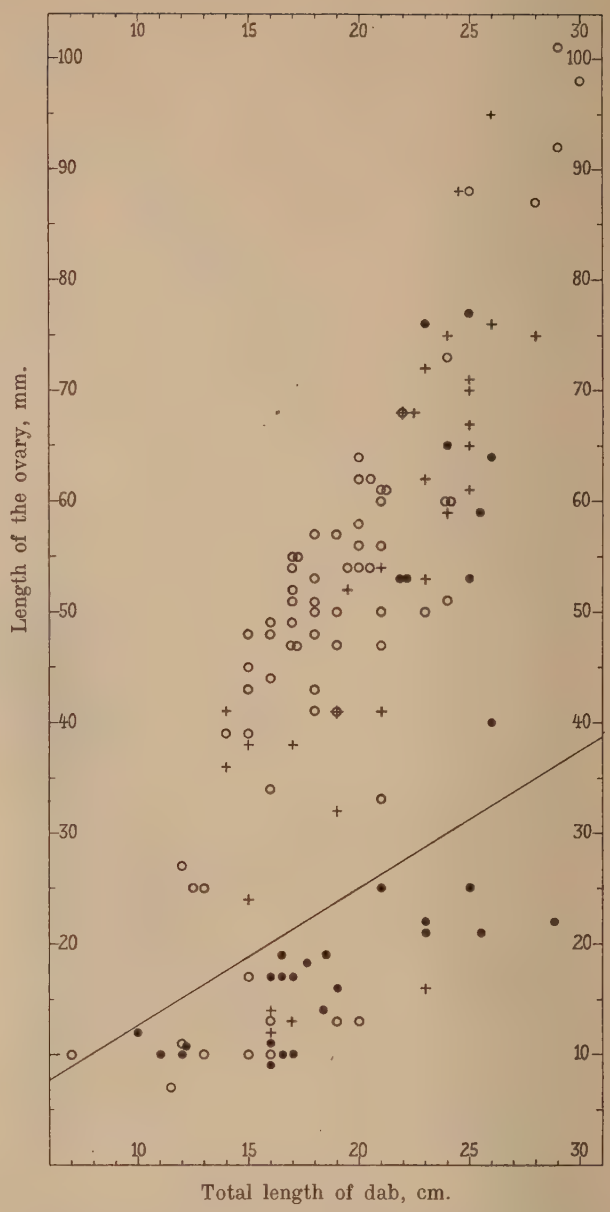

Fig. 4. Length of the ovary at different length of the dab during May 1935, 36 and 37
in the Northern Belt Sea: +
in the Southern Lillebelt and Western Baltic: ○
in Faxe Bay and South of Møen: ●

Examined by	Year	Mean of anal fin rays	σ	σ_m	σ_σ
Mortensen ...	1895	54.00	1.83	0.18	0.13
Johansen	1906	54.50	1.97	0.20	0.14

In comparison with the results from the researches in the Kattegat during recent years (cp. Table 1) the investigations of 1895 and 1906 show very low values. The samples are so large, that the difference found between the mean numbers of the two years and those determined during recent years is beyond doubt.

A look at Table 2, which states the average num-

bers of anal fin rays of the different year-classes of dab inside the individual areas, will show that these numbers seem to exhibit a rising tendency during recent years. So it seems that an alteration in the racial character of the dab of the Belt Sea takes place during recent years coincidently with the one proved by A. C. Johansen to occur in the plaice population during the last decennia; in the case of the dab, however, the change also appears to include the Kattegat.

IV. The shape of the dab.

It is well known that the North Sea plaice and the Baltic plaice show different proportions between length and breadth. It must be supposed that this difference is to some degree determined by race although it has been pointed out that the shape of the North Sea plaice after a transplantation to the Belt Sea will alter in the course of 6 months in a way as to approach to that of the Belt Sea plaice[1]).

A corresponding difference is found if we compare the proportion between the length of the head and the total length of dab from various localities of our waters.

Given the same length the dab has the broadest body at Bornholm and the narrowest one in the Horns Reef Area, the dab of the Belt Sea and the western Baltic taking up an intermediate position (cp. Figure 2). However, the proportion between the length of the head and the total length of the dab seems to present a rather small difference in the Belt Sea and at Bornholm, whereas the dab of the Horns Reef appears to have a comparatively longer head than the dab of our inner waters (cp. Fig. 1).

V. Age and length of the dab when attaining sexual maturity.

The approach of the maturity of the dab appears in the female fish from the increase in the size of the ovaries. For the purpose of examining the difference in the development of the ovaries, partly within the same area, partly from one area to the other, I have measured the length of the ovary in a considerable number of dab[2]). Some of these measurements are given in the Figures 3 and 4.

Figure 3 shows the proportion between the total length of the dab and the length of the ovary at various depths of the northern Belt Sea about May 1st. Unlike the state of things in autumn the differentiation of the stock with the depth is not very pronounced at this season as far as the development of the ovary is concerned.

So we may at this season compare the different areas without paying any regard to the depth at which the dab was caught.

Figure 4 brings a comparison between the development of the ovary (in May) and the length of the dab, 1° in the northern Belt Sea, 2° in the southern part of the Lesser Belt and the western Baltic, and 3° in the Faxe B. and S. of Møen. We note that the development of the ovary in the two areas first mentioned is rather uniform, the third area, however, differing very much from the others: in this area the dab is still immature at a length of about 20 cm., whereas the majority of the Belt Sea dab in May are on the point of spawning already at a length of about 15 cm. The dab of the two areas exhibit practically the same racial character (cp. Section II), and so we see that the outspoken variation of the length (or age) at which the maturity begins within the same race is caused by other factors than the race, most probably by the different hydrographical conditions.

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[1]) Aage J. C. Jensen: Some Factors influencing the apparent and the actual growth of the plaice and dab. Rapp. et Proc. Verb., Vol. CVIII, 1938.

[2]) The length of the ovary was measured on the lower side of the dab from the front edge of the interhæmal spines of the anal fin.

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